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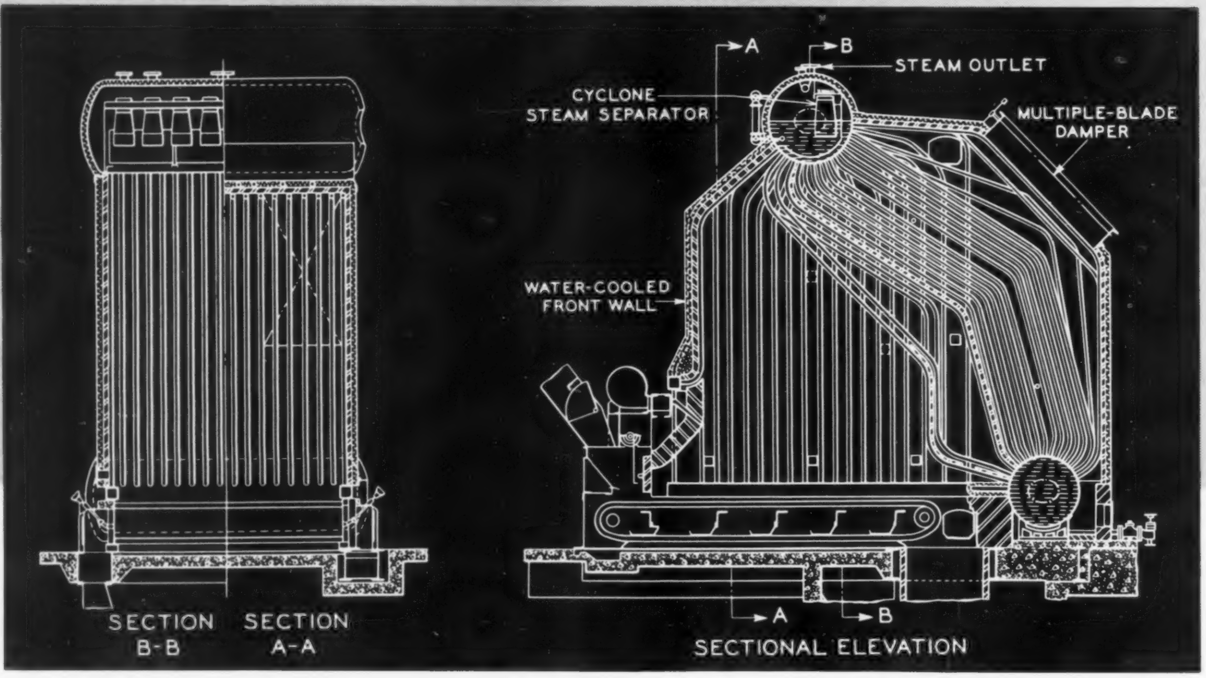

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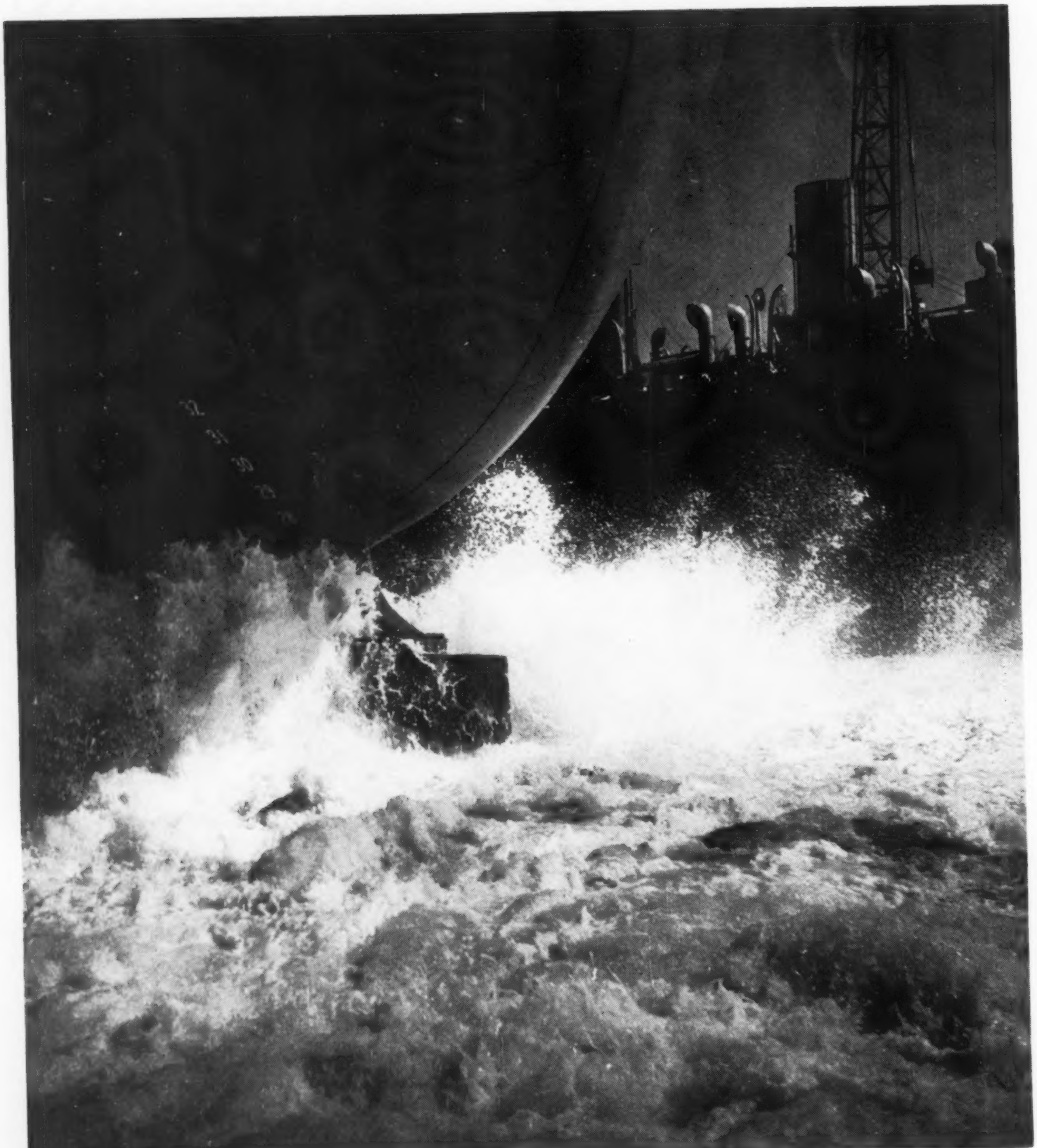

dmitri kessel

Trying the Propellers

Volume 64
No. 7

MECHANICAL ENGINEERING

July
1942

GEORGE A. STETSON, *Editor*

Preparedness

TOTAL global warfare, now almost completely mechanized, has inevitably magnified the importance of production—especially mass production—and the management of industrial enterprises. Granted that warfare is still the soldier's business, as General Somervell pointed out in his Washington address (see page 518), the soldier's weapons and equipment have nonetheless been multiplied in number and in their complication. Hence, the task of supporting the Army, the Navy, and the Air Force calls for a drain on accumulated stocks of materials and tools, and upon all that production, raw-materials resources, and tool manufacturers can provide. Furthermore, it demands a prodigious quantity of man power, not merely for the fighting forces and their auxiliaries, but, in ever greater numbers, for the industries and services of supply. Added to these problems and greatly complicated by numerous distant areas of conflict and defense is the task of providing transportation under the hazardous conditions of submarine warfare and the necessary shift of normal routes and carriers.

Preparation for the kind of war in which the United States finds itself engaged is a complicated and many-sided affair. From the military angle the long years of planning for M-Day were conscientiously and intelligently carried forward on such basic assumptions as to the equipment needed and the sources of materials as conditions justified. That more adequate provision for the needs of the Army, the Navy, and the Air Force was not made can be charged to an apathetic public and to a noisy opposition. Appropriations for all branches of the military services were niggardly, and, in view of what was brewing in Europe and the Far East, they offer pitiful evidence of blind and wishful thinking.

From the psychological angle the traditional reluctance of a peace-loving democracy to believe in the inevitability of war was intensified by the efforts of assorted groups of isolationists, appeasers, idealistic pacifists, debunkers of history, disillusioned citizens who had made sacrifices in an indecisive war of a quarter century ago that ended in a vindictive peace treaty, and all sorts and conditions of men and women too intent on their own personal fortunes and misfortunes to think clearly about the wiles and woes of the rest of the world. The long period of slow awakening, rudely ended by Pearl Harbor, was an apparently essential conditioning prelude to active participation. Even today, preparation on the psychological front is far from complete. Overcoming the inertia of business as usual and reluctance to face up to the realities of a desperate situation requires the sharp spur of the almost dictatorial powers of the federal government. Preparedness on this psychological front has been tragically belated.

The brightest aspect of preparedness is to be found in industry itself. Not that industry is or was in any sense war-minded or had widespread experience in producing the weapons and equipment of warfare beyond the training of the first World War and the few "educational" orders placed with some manufacturers by the Ordnance Department. For a war depending on production, however, the United States was as well prepared as any democracy could be. For the task the war has forced upon it, it was more competent than other nations whose peacetime activities were not concerned as greatly as ours is with mass production and effective management. The fact that we were a bathtub, electric refrigerator, automobile, and radio minded nation brought upon us slurs that amused some and irritated others of us. Our concern with material prosperity was a source of pride or a subject for apology, according to individual taste. However, it is serving us well today in our attempt to become the "arsenal of democracy" and is likely to prove the salvation of all democracies.

What American manufacturers have been doing for the last hundred years has been more than supplying the material needs of homes and markets. They have been learning the technique of production by machine—that fearsome Frankenstein periodically summoned by well-intentioned Jeremiahs to frighten us, but put to useful work by engineers whenever the need arises to give the public what it demands. In peacetime it alternately satisfies these demands and gluts the markets, but in wartime it springs into action with a phenomenal energy and adaptability, taxing our capacity to feed it raw material, to service it with man power, and to carry its products to the market. What the product is, is relatively unimportant. Anything is grist to its mill, once we allow time for the change-over from sewing machines to machine guns, from automobiles to tanks, because engineers have learned the art of production. Once the production lines are set, the steady flow from receiving room to shipping platform responds to the skill of the production engineer. Time for tooling up is, of course, essential, but even engineers have been amazed at the production records that have bettered time schedules.

Industrial production is always in a state of preparedness in the United States and needs only the stimulus of an active market to call it into being. Current history is demonstrating this fact.

More Preparedness

IF we may believe that the record of conversion and industrial production demonstrates that engineers and manufacturers were in a state of preparedness for war because they had learned so well the techniques of production and management, we may safely count upon engineers to undertake the task of reconversion whenever conditions demand it, provided markets, in their broad sense, are able to absorb goods.

There is much talk about winning the war first and planning the future when victory is assured. No rational person wants to put the cart before the horse, wants to forget the necessity of victory as a starting point for a better peace. But are not the abrupt changes from peace to war and from war to peace more apparent than real? Is not today the child of yesterday, and will not tomorrow grow out of today? Unknowable factors will arise to condition events, to confound prophets, and to discomfit planners, but if the fabric of national life is soundly woven day by day, the pattern superimposed upon it will be of little real consequence. What we have to concern ourselves about principally is the soundness and quality of the fabric, to take whatever woof the shuttle holds and interweave it skillfully with the strong warp of human purpose. It is too much tampering with the machine and failure to keep it running that we must guard against. The future must not go by default to the defeatists, the opportunists, and the busy but impractical planners who would throw out the machine and reconstruct another in the resulting chaos.

The war is giving a powerful impetus to our production techniques and our production capacity. We shall need both in the trying days of reconstruction and reconversion. Just as we found that production engineers and industrial managers had been quietly learning how to meet the crisis of a war of machines and materials, so we shall find that thousands more are now learning the skills the world will need tomorrow. If we can make sure that these skills are to be exercised in a free world of freedom-loving and liberated human beings, the result will be a peace according to a broad plan of human advancement in a world of more abundant opportunity, not for competitive destruction but for the growth and satisfaction of the individual. We know now that our production skill is equal to any task laid upon it provided the economic and social conditions in which it must operate are intelligently controlled. In this area we are steadily strengthening preparedness.

Education Needed

BECAUSE we have the production skills and seek the properly conditioned economic and social environment in which to bring them to full fruition, we must strengthen our educational processes and objectives. We know now that the task ahead will be long and hard. We know that the public has been impressed with the manner in which engineering and industry are serving it in total war. We know that the public is becoming increasingly conscious of the essentially mechanized character of its manner of living. We know that the public will expect engineers to develop even more fully this mechanization of its way of living and that it will become ever more completely dependent on an industrial type of civilization. We know also that we and the public must learn how to live in such a civilization. We all need education.

The overlapping of one era of civilization out of which we are emerging into another in which we begin to realize we must live accounts in large measure for the trials the world has been suffering ever since the dawn of the century. As we draw further away from the old and penetrate further into the new we should, if we are wise and intelligent, enjoy more of the fruits and suffer less from the unexpected hazards of a changing mode of life. Traditional attitudes of mind, the inertia of custom and prejudice, the forms by which society regulates its interrelationships, conspire to make progress slow and painful. The world has been through such evolutionary and revolutionary experiences before, and, on the whole, it has emerged into eras of peace and progress that mark advances in human dignity and satisfaction. We may confidently expect that we shall eventually emerge into another such era, that we shall top the rise and find ourselves on another plateau of human achievement. What we shall find there is obscured today by the rim of that plateau which forms our immediate sky line.

Shall we know how to live on this new plateau? Surely, not at once. New leaders, new techniques will be needed to supplement those we are developing now. Because our life will depend largely upon science and technology, shall the scientist and the technologist be our leaders? Eventually we might be better off if men of a scientific attitude of mind and equipped with technological skills and experience were to provide a greater number of our leaders. To achieve this condition, however, education is an important prerequisite. It will be education of a two-way type. On the one hand the great mass of the public must be brought up in a system of education that is designed for living in a technological world. Men must train themselves for the jobs they will have to perform in such a world and not for the jobs that were performed in the world from which we have emerged. Learning how to make themselves fit into such a world will inevitably bring to them clearer understanding of the rational approach. On the other hand, those who comprehend the realism of the technological way of life must learn to comprehend also the inconsistencies of the emotional way of life.

Where engineers and scientists fail in leading the people is in lack of understanding of people and their emotional responses. As has been said, it is not enough to be right, one must be persuasive; and being persuasive is the art of the statesman. If engineers and scientists are to become leaders of the people, they must become great statesmen. The task of education is to teach the people to understand how science and technology condition the world in which they live, and how to adapt themselves, and to teach scientists and engineers to understand the people and how to become leaders.

The ENGINEER'S JOB *in* WAR PRODUCTION

Addresses at the All Engineers Dinner, Washington, D. C., May 18, 1942

WHAT turned out to be the largest of the annual All Engineers Dinners ever held in Washington, D. C., took place in the ballroom of the Mayflower Hotel on Monday night, May 18, 1942, with a total attendance of 1280. The demand for tickets was so great that 400 latecomers were turned away after the capacity of the ballroom had been reached. Sixteen engineering organizations participated in this dinner, and the subject of the addresses was "The Engineer's Job in War Production." Frederick M. Feiker, dean of engineering at George Washington University, presided at the opening of the after-dinner session and introduced the toastmaster, James W. Parker, president of The American Society of Mechanical Engineers. The speakers were William L. Batt, Chairman of the Requirements Committee of the War Production Board and past-president A.S.M.E., and Lieut. Gen. Brehon B. Somervell, Commanding General, Services of Supply, U. S. Army. Mr. Donald M. Nelson, Chairman, War Production Board, was to have been the third speaker but he was prevented from attending by the pressure of last-minute business.

The dinner was held under the auspices of the following engineering organizations: American Association of Engineers, American Institute of Chemical Engineers, American Institute of Electrical Engineers, American Institute of Mining and Metallurgical Engineers, American Society for Metals, American Society of Agricultural Engineers, American Society of Civil Engineers, American Society of Heating and Ventilating Engineers, The American Society of Mechanical Engineers, American Welding Society, Army Ordnance Association, Institute of Radio Engineers, National Society of Professional Engineers, Society of American Military Engineers, Society of Automotive Engineers, and Washington Society of Engineers.

Dean Feiker acted as general chairman of the dinner committee, of which Martin A. Mason was secretary-treasurer. The Arrangements Committee consisted of M. X. Wilberding, Meiric K. Dutton, and Mrs. Lacey W. Coad.

From the stenographic report of the meeting, the remarks made by the toastmaster, James W. Parker, before and after the speeches, have been condensed to form the first of the three articles that follow. The addresses of Mr. Batt and General Somervell are also presented.

Our WAR—*Our* PEACE[1]

By JAMES W. PARKER

PRESIDENT, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

TOASTMASTER'S REMARKS PRECEDING THE ADDRESSES

NOBODY even in the last war knew what heights the productive capacity of the United States of America would attain—knew what it meant, really, to turn the energies of this people in one direction. Nobody knows what we are doing right now. As someone put it the other day, for the first time we have been able to throw the switch in and leave it in. Before now we have been wondering what would happen if we really put the productive energies of the machine to work. We had never been able to leave the switch in for very long.

But now, we have put a full load on our machine and we are running it ungoverned by the ordinary economic considerations that prevail in peacetime, without such checks as competitive market conditions, without financing limits—at least to all intents and purposes without financing limits. Its output is now limited only by the physical capacity of the machine itself, by our ability to find raw materials from sources all over the world, and by our ability to transport these materials.

It appears that the construction of this great productive system is approaching completion. Its elements are gradually being synchronized. Its circuit breakers are being closed. Now comes the work of grooming and manning the machine and keeping it maintained and running. There is much still to be done.

Above all things it seems to me important that the thinking men of the country make some effort to understand the forces that are at work in order to discover the means necessary for increasing the desired result and for controlling this machine when once it is up to speed. I think it is likely that men of the very group we have here tonight—types of men like these—are best able to understand the implications of their work. The two speakers who are to address you tonight are competent beyond most to drive home to each of us individually the responsibility for the further conservation of our resources, our materials, our man power, with all that these things imply, involving as they do further conversions of existing manufacturing facilities and still greater ingenuity in improvising new methods to effect these purposes. It is for that reason such a meeting as this has been organized and that these particular speakers have been invited here to discuss these matters with you.

TOASTMASTER'S REMARKS FOLLOWING THE ADDRESSES

Before we close this meeting I should like, if I am able, to say some words in the way of summary; to explain, if you please, to our own speakers why we are here, why this meeting is being held.

[1] Condensed from stenographic report of the dinner.

The engineers, the productive men of this country, are turning into this job amazing amounts of skill. They are going at it with tremendous courage, as are the commercial privately organized corporations by whom most of them are employed. As one goes around the country he finds no indications that American manufacturers are lying back. The engineers, too, are going about their jobs in traditional fashion. I suppose if I speak of the organized engineering associations going about the job in traditional fashion you will probably say to yourselves, "That means doing a lot of talking." This is perfectly true, there is a lot of talking about it, but I believe this talk has been to good advantage. Meetings of specialists have been held all over the country—every organized society has been carrying them on—meetings devoted to specialization at which experts have told those just turning their hands to these new tasks how they have gone about it. They are trading machines, they are trading skills, in the town of Detroit—and in every one of these great manufacturing centers you see the same sort of thing going on.

We are witnessing a phenomenon—a great, peace-loving, easygoing, self-indulgent people turning their attention to a stern task. I think the American people know it is a stern task. I think the men who are going into the fighting forces are going at it with a strangely quiet, sober, and steady spirit, with a smile, to be sure, but with a very keen understanding of the job and its seriousness. There is little drum beating, there are few bands playing, but the men are going into the thing steadily just the same, and so also the civilians are turning their energies in the same direction.

I want to say just one more word of what seems to me to be the duty laid upon the engineers of this country. I do not think we are called upon merely to go on in this traditional way but rather that we are called upon as educated men and women to give some thought to where we are going—to the implications of this job. I think we should realize that this is, after all, a war undertaken by the American people. It wasn't Congress that made up its mind; it was the American people that made up Congress' mind. When the American people ever arrive at what my friend Dean Sackett has called a mass decision, be assured Congress will carry it out. Congress will do as it is bidden.

If that is the case, there is laid upon all the educated men of the country the great burden of forming that public opinion. It is not to be expected that every man in the street, every man, woman, and child will get these things straight. They look for leadership to their neighbors. The workmen in our plants and manufacturing establishments habitually look to the engineer for guidance in technical matters; and, whenever the engineer has exerted himself as a leader in his own particular group they look to him for leadership in their everyday thinking as well. The engineer has not always risen to that opportunity. Had he exerted the leadership that opportunity gave him many men would have followed him rather than certain of the labor organizers whose statesmanship has been so faulty.

I say again that the burden and the task are laid upon the educated men of this country to understand what kind of a world we are heading for afterward. We must not let some pressure group, some political group, do our thinking for us afterward. This is *our* war, this is *our* bitter experience. It is up to you men, who, I still maintain, are the natural leaders of the country, to exert that leadership and make yourselves felt, each in your own community.

I am sorry that Mr. Donald Nelson could not have been here. To me it is significant that a man with his type of training, who has spent all his years in the active management of large business affairs, is the man that the country turns to for this great job of organizing which he has undertaken. That is typical of what the Government is doing everywhere—it is turning to the men of capacity and of experience to carry on this job. It isn't a job just for the politicians. It isn't a job just for men in the various Government departments. This is a job for the people of the United States of America.

We are living not merely in parlous times; we are living in exciting and stimulating times. I have every faith in the world that the American people will respond to that stimulation.

HOW ENGINEERS CAN SPEED VICTORY

By LIEUTENANT GENERAL BREHON B. SOMERVELL

COMMANDING GENERAL, SERVICES OF SUPPLY, U. S. ARMY

SOMEONE has called this war a war of gadgets. Someone else says it is an engineers' war. It is a war of production; transportation; a war in the sky; a war on wheels; a civilians' war.

Let us not quarrel about nomenclature. Call it what you want. If four-motored bombers and thirty-ton tanks are gadgets, then it is a gadget war. Engineers, scientists, shop laborers, air-raid wardens—all have their highly important jobs to do.

The fact remains that this war, like all others, is a soldiers' war. The basic strategy employed today is the same strategy that Philip of Macedon used on the Plains of Thessaly twenty centuries ago. His phalanx was a striking force armed with every known weapon. It was armored with breastplate and casque. It depended for success on superior man power and mobility, upon superior weapons and supply, and upon superior discipline. It executed commands faster than its enemies; it had more catapults and spears, more men in the back areas bringing up supplies. It was a new idea. It used what today we call the scissors movement to cut up its foes. It took sharp advantage of surprise. It introduced terror as a weapon—terror inspired by a vast, moving, shouting army with banners. It laid waste the cities by fire. The Greeks had a word for it and that word wasn't "blitzkrieg."

Hitler and the Japanese have no copyright on military genius. Their sole advantage has been discipline and a head start. While we pursued our peaceful vocations, while we explored new paths of peace, while we searched new frontiers in art and science, while we sought new freedoms, new hopes, new comforts for mankind, they were brewing their kettle of violence.

They have won the initial stages of this war not because they are more skillful, not because they are more clever, not because they are more courageous. They have won because they had been preparing for a long time. But it is not the preliminary battles that count. The last battle is the one that

is written down in history. When we win that last battle it will be because we have organized our soldiers and our supplies and our civilians in greater numbers and with greater efficiency than our enemies. If we win—when we win—it will be because we have achieved discipline on the home front as well as on the battle front.

Against Hitler's and Japan's decades of preparation we have been in this war only a few short months. We have moved fast and far; we have shaken off our cloak of apathy; we have fallen into step—one hundred and forty million of us.

Five months is only a little while, but we have gone a long way. The road ahead of us is dim with the dust of battles we have yet to fight. How long that road is no one can know, but it is shorter than it would have been had not our enemies misjudged us and themselves.

When Hitler put this war on wheels he ran it straight down our alley. When he hitched his chariot to an internal-combustion engine he opened up a new battle front, a front that we all know well. It's called "Detroit."

When Hitler took this war into the skies he rose into our own element. We will meet him there on our terms. We are meeting him there already. From Brest to Berlin he feels our strength, and as the days of summer lengthen he will feel it again and again, without respite, we hope.

When Hitler brought civilian populations into the war as innocent victims, he unthinkingly brought in the German people. He had shouted his way into their confidence; he had attacked other peoples ruthlessly and with cruelty and had tried to justify his acts by saying that such a fate could never be visited on his own race of supermen. And now that the German people are beginning to feel our wrath, and as a thousand of their cities and towns soon will feel it, they will know that Hitler's promises are not to be trusted. Hitler will meet a new enemy. That enemy will be on the home front. It will be his own people, and retribution will be swift and merciless.

How long we must persevere before these things happen we do not know. We do know that by skillful planning and by courageous action we can speed the day. If we work and fight together with singleness of purpose, and if we strive alone, each in his own job, making each day and each hour and each individual minute count, we will assure victory.

You engineers ask what you can do individually. This is what you can do. You can double your effort on every task you face, whether that task is concerned directly with the armed forces or not. For no matter what your engineering field, no matter what project you are working on at the minute, it's all part of our united effort.

The sixteen societies represented here tonight span the field of engineering knowledge. Whether you are engaged in civil engineering, electricity, chemistry, radio, or metals, your contribution can be direct and it can be far-reaching. If you by your skill can contrive to save a single hour of a single worker's time, if you can save a single pound of steel, if you can find a good substitute for a single strategic material, if you can evolve workable shortcuts in conversion, if you can dig out old, idle machines and make them productive, then you are doing your share in winning the war.

That is your job. You are trained for it. You have the background and the experience. If each of you this day should add to that experience an unshakable will to help, and help, and to keep on helping, no matter how hard it is, then the war will be shorter than we anticipate.

I especially commend to the attention of those of you in transportation the unhappy fact that transport, afloat and ashore, is our greatest problem. Our tank factories and our plane factories are turning out machines in numbers that would astound and dismay our enemies. Our task is to get them where they are needed by the shortest route in the shortest possible time. If one of you transportation engineers can figure out some way of increasing our transportation efficiency, and put that scheme to work, you will be a national hero. I urge you to try to help us on this.

The rest of you, no matter what your field, can give as great aid in other areas. There is no time now to go about pointing out what we need. There is no time to ask for individual ideas. As you evolve them out of your experience and your imagination, offer them to the agency they will aid, be it railroads, buildings, steamships, aircraft, cannon, or any other item of military activity.

Your ideas and the ideas of the others, your sweat, your sacrifices, your determination, combined with theirs, will lead us to victory.

WAR PRODUCTION—*The* TASK *of the* ENGINEER

By WILLIAM L. BATT

CHAIRMAN OF REQUIREMENTS COMMITTEE, WAR PRODUCTION BOARD

IF ONE looks back into the early days of warfare, it is perfectly obvious that war was largely a conflict between two people or, on an amplified scale, of two groups of people. As wars have gone on they have become increasingly complicated with men's knowledge and skills. Certainly, more and more, war has become a conflict of materials and management, of science and engineering, to the point where this war fails to follow the pattern of any of its predecessors because each of those factors is enormously accentuated as compared with the problems which surrounded any one of them in earlier wars. I am not conscious that in the last war either England or the United States had any considerable problem of materials nor, as today, of management, nor had science and engineering promised to play the part in the final victory which they promise to play in this war.

It would be impossible for me, of course, to talk about this problem to engineers without spending some part of my time on the subject of materials, and I do that, as I indicated at the outset, with a great degree of trepidation. We Americans have overlooked the fact that while we are the largest consumers of materials, we have always been the largest importers of materials. Some of the critical items on which our economy has been based—tin, rubber, nickel, and, in the medical field, quinine, and a whole string of chemicals—have been entirely

imported, with no resources in this country of any one of these strategic items. In a field closely related to these critical items but of which we have had some resource are such common but essential materials as tungsten, chrome, manganese, and vanadium which we have thought of as being so inextricably a part of our economy that they were ours.

Certainly no earlier war in which we have had a part has been so large a consumer of so much of these materials as this war. Indeed, no peacetime year has consumed quantities remotely touching those which are called for today. Of course we never had an economy in which in one year we had, as we promise to have this year, between 110 and 120 billion dollars of national income, and certainly we never had one in which the volume of production was so largely made up of heavy goods as it promises to be this year. The toll of iron and steel and of all metals is greater because of this. It is, indeed, far greater than we ever dreamed could be called for.

Today, I think it must be fairly said that our war program in many ways is directly measured by the amount of materials available. Let me take steel plate as an example. We are producing now approximately twice as much steel plate as the country ever produced before. That increase has been brought about in not much over a six-month period, and yet we do not have enough steel plate to satisfy the insistent and entirely justified demands of the services. It has reached a point where, if more steel plate is needed in any one month for one claimant, it has to be taken away from some other valid claim. The choice between one call and another is a difficult one, because each has involved in it some essential aspect of military strategy. It may be ships and guns on the one hand; it may be tanks and planes on the other. It is an unfortunate fact that those who have to do with the distribution of materials have constantly before them the fact that today when more material is given to one of the elements of the military demand it must come out of something else of military importance.

I have come to one conclusion, and I think this is the only conclusion in these random remarks to which I would hope you would give some special attention and join with me in not forgetting: I am convinced that for the future protection of this country, one of the essentials against another emergency of another day (which, pray God, may not happen but which may) is the provision of a few critical plants to produce critical items not needed in peacetime or not needed to such a degree in peacetime as in wartime. Those plants probably should be locked up in the peacetime period and should be placed in operation only when the demand warrants. In the last war, one of the "tightest" materials was wide plate. From 1918 down to 1940 and 1941 there has been no problem of wide plate, but here it is on our hands again, just as critical as it was in the last war, if not more so. Hence I say that it is important to the protection of this country that we shall build some such plants not needed in peacetime and lock the door, with the certain knowledge that if we get into war again we shall only need to turn the key and put those plants to work; and further, that we shall never again find ourselves without substantial storage stocks of critical materials.

Long before this war broke out the Army and Navy Munitions Board had been making every effort before the Congress to see that there were ample reserve stocks of critical materials, some of which I have named. It was only after the defense program began, and then too late to accomplish much of value, that very small appropriations were made available for strategic stock piles. Therefore, in addition to the suggestion that we build for ourselves in peacetime unneeded wide-plate mills, I say that we ought to lay by substantial stocks of strategic materials, locked up against some future need.

Having reached, as we apparently have, the present practicable limit of the development of new sources of raw materials in any substantial degree, I come to that job in which the engineer is able today to render, and is today rendering, the greatest possible service to the military program. That is in the development of these resources which I call "mines above the ground." These mines above the ground are, broadly speaking, in two areas. One of these areas is the saving of wasted material, in other words, the better utilization of scrap. The importance of scrap today can hardly be exaggerated. I have sometimes said that the scrap man is now indeed an honored part of our economy, because without him we should be in a much more difficult state than we are.

I went through one of the large steel plants in Chicago yesterday and was distressed to see the storage capacity for scrap which normally would occupy a space many times the size of this dining room and which had on it hardly more than a handful of scrap. The engineer has a large part to play in helping to get scrap—segregated scrap, carefully separated scrap—back into the system. We have been an extravagant people. We have always had so much material to draw on. We have never needed to think in terms of saving. One of the lessons which the engineer must teach in this war program is the lesson of saving of materials and the avoidance of unnecessary waste.

The second contribution which the engineer is peculiarly fitted to make is in the area of specifications. Again, as with the initial usage of our raw materials, we have been wasteful in specifications. If a little nickel was a good thing to put in steel, a little more nickel was good because it did no harm. I have sometimes said that we had developed our heat-treating specifications with so much nickel that a blind man could heat-treat that steel on a dark night.

Economy in the use of these critical materials will not be a hardship. I remember one of our earlier experiences when we were attempting to cut down the use of nickel and had requested larger users to cut nickel consumption as nearly as possible by twenty per cent. One manufacturer of gear blanks came to us and said he didn't see how he could reduce the nickel in his specification but he wondered if he would meet our objective if he were to reduce the weight of the gear by twenty per cent by drilling holes in the web. The answer was, yes, that would be perfectly all right. Now, the interesting thing was that he came back to us sometime later and said, "I saved the twenty per cent of the weight of that gear blank and therefore twenty per cent in nickel, but the interesting thing is that I have got a good deal better gear. It heat-treats better and it is much quieter, and I am eternally grateful to you for putting the pressure on me."

All steel specifications must be reviewed, because that is our only hope of getting through this program with anything like enough of the critical alloys called for by the program. Savings are possible. They are being made. The co-operation of the Army and the Navy and of the other services in the reduction of critical alloys in their steels has been splendid. There is a hope that by the reduction in nickel alone we shall be able to save about twenty per cent of the amount of nickel which is being used today and, I assume, without in any way affecting the product to its disadvantage.

On the subject of nickel (these figures which I have are not in any sense secret; they have been published many times in technical journals), I would like, when we talk about shortages, to remind ourselves that the greatest amount of nickel this country ever used in one year prior to 1942 was about eight million pounds a month. That quantity today has doubled, and if we had fifty per cent more we would have just about enough nickel to supply the pressing requirements. That difference can be saved. Most shortages can be met if engineers will critically review their specifications and if they

will cut the use of alloys down just as far as may safely be done.

In the field of construction the job of the engineer today is not to build the best building he knows how to build, taking as much steel as possible, but to build a building that will do the job over the comparatively short period involved with the use of as little steel as possible, because this steel program in the structural field cannot be met if our past standards of construction are to go unchanged.

I make a statement that I am sure will bring challenge when I say I am convinced there is enough material in this country to win this war, but with the stipulation that that material must be husbanded carefully so that no pound of it is wasted by an unnecessary specification, by bad planning, or by bad scheduling. When the materials in this country are husbanded by careful and informed people I am convinced there is enough material to win this war. If you are minded to challenge that statement and take the other side of it, then of course you would have to conclude that we were not going to win the war. And that brings us to that problem of management.

I heard a review this afternoon of the reasons why production was not going along as speedily as had been hoped. As usual, the first reason was lack of materials. I would like to say for the men who spend their lives—and rather difficult lives they are these days—on raw materials, that materials are all things to all men. The airplane builder looks on materials as everything that comes in his door, from engines and radio instruments down. We customarily think of material in that broad, inclusive meaning of the term as something that somebody else furnishes for us. The No. 1 complaint was inadequate materials. There were other complaints that had to do with labor and with red tape in government. I listened, in the whole of that series of reasons why production was not going as it should, for some reference to management, but there was not a single comment about inadequate management. I know you engineers will agree with me, and I think every engineer in this room is convinced, that management has yet a big job to do. We think, because we have been raised at Taylor's knee, figuratively speaking, that the lessons of management are familiar to us. I am convinced that management has just as much to contribute in the way of improved methods, better technics, and greater ingenuity to making the supply of materials go around as any other factor.

In a speech some months ago, Mr. Nelson said that, in the field of aircraft engines and propellers, if the thirty some odd manufacturers were as good as the top three, the output of that group of essential parts would be up a little more than twenty-five per cent. In the machine-tool field, in which he listed 153 manufacturers, he said that if they were all up to the limit of performance of the top three, the production of the machine-tool industry would increase forty-five per cent. This war cannot be won without the best management.

One of the factors which management has to face today as it never has had to face it before is the time factor. A man who built a refrigerator or a radio or any one of those items of our familiar life of a few years ago had no special time factor to consider except as he might miss a market. Today, time is *the* vital element because the battles which General Somervell will fight next spring will be fought with the goods we are producing this summer. Every month, every week, and without exaggeration I think one can safely say every day, the additional goods that are turned out above those that were expected will definitely and directly influence the course of the war. So it is no exaggeration to say that one of the pressing problems on management's shoulders today is to increase production. A good job is being done; by normal standards an excellent job is being done; but no performance is good enough in the face of these pressures.

Management has more problems with labor than it has had before. Some of these are new problems, because labor, having given up the right to strike, has a valid reason for asking of management other guarantees and other assurances; I have the hope that we in management and the leaders of labor may learn something of long-time significance for the future out of this peaceful relationship which must prevail today.

It seems to me that as never before there is a challenge to science and to the laboratory. It has been said that we are not using the laboratories of the country as thoroughly as we might, and I hope that more attention will be paid to that factor when some of the immediate urgency of the first steps of the laying of the foundation of this new structure shall have been taken.

I have been interested in the stress which Mr. McNutt, the new chairman of the Man Power Board, has laid on engineering education. It is a novelty to hear a man not an engineer point out that if our engineering education is allowed to lapse, if our teaching of physicists, indeed, our teaching of mathematicians, goes by the board, this war effort will directly suffer.

It has been said that industry and some of the agencies of government this year will want eighty thousand engineers, and I have been told that the services would want in the neighborhood of nine or ten thousand engineers in 1942. I tried this figure on General Somervell and I have his opinion that it is not large enough by half.

These are the challenges which the engineering profession has before it. I have great confidence, as you have, that once the engineering profession is harnessed into this job, as I believe it has not been harnessed so far, it can make a contribution the like of which we ourselves do not fully comprehend. When I see this great gathering of engineers, the most brilliant technical minds of the country, gathered here in this one city, I am convinced that we engineers do not know how good we are. It is up to the services and up to the War Production Board and up to the other agencies of government to harness our abilities so that we contribute that which we uniquely can contribute as no other profession can.

Air-Raid Damage

At a recent meeting of the Institution in London, considerable interest was aroused by a paper presented by Mr. Hal Gutteridge entitled "Proneness to Damage of Plant Through Enemy Action." The aim of the paper is to draw attention to the facts which underlie the rapid approximate estimation of damage to plant through enemy action.

Different items of plant will be affected to a greater or lesser extent depending upon their type and the conditions to which they have been exposed. Thus, a smith's anvil, at the one extreme, would be slightly damaged by blast, fire, collapse of the building, falling debris, or flooding, if a direct hit or persistant fire was excluded. At the other extreme, delicate electrical apparatus would suffer severely if exposed to any of these conditions. In the case of the anvil the "damage proneness number" (d.p.n.) is likely to be between the limits of 0 and 5, while that of the latter may be between 80 and 100 in "average" cases where a direct hit or persistent fire did not take place.

Thus all plant can be classified and given probable limits beforehand of the extent of damage, and it would remain for the trained observer to fix the damage proneness number which in exceptional cases might be outside the average limits.

Expressed as a percentage of the value of the item, the damage proneness number would indicate the amount of the loss involved; the sum of the amounts of the individual losses would give the total approximate loss.

THE PROBLEMS OF MANAGEMENT[1]

By WYMAN P. FISKE

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At a time when success in our war effort so obviously depends in very considerable part on the production of war matériel, good management is a national concern. Yet management is operating today under the most trying of conditions. War production requires either a drastic change in the nature of the product or rapid expansion of existing facilities. One executive of a nationally known concern pointed out that in the case of his company war meant (1) the total liquidation inside of two years of a business with a normal annual volume of many hundreds of millions of dollars and (2) rapid conversion to an even greater production of war products totally new to the organization. The management problem presented by such a situation is beyond the comprehension of most of us for the simple reason that the nature of our experience limits our understanding of a problem so vast. It is enough to tax the capacity of even the most experienced of managements.

Many hitherto small companies have been forced to expand their rates of production manyfold. The aircraft industry in general has compressed into a very few years a total expansion equal to and even exceeding that accomplished by the automobile industry in well over a quarter of a century. One instrument company found its production requirements to be multiplied by thirteen over any previous experience. It became necessary to use practically every really experienced workman as a supervisor responsible at once for training new employees and getting out production.

BASIS FOR OBJECTIVE PLANNING

With conditions like these commonplace, any contribution to assist management in its increased responsibilities is welcome. The recent publication[2] of the results of a research study of the management policies and practices of thirty-one leading industrial corporations, conducted under the auspices of the Graduate School of Business at Stanford University, is more than welcome. It should be a real boon to harassed managers, for it is an entirely competent report including what probably can be considered the best practice in the United States. In the words of Ralph K. Davies (now Assistant Petroleum Co-Ordinator, but formerly vice-president and director, Standard Oil Company of California), "it will answer an obvious need for enlightened and dependable information as a basis for objective planning of management, free from personal influences and traditional habits of thought."

The value of an investigation, by an independent group, of top-management practices in the fields of organization and control is fairly obvious, yet the particular circumstances leading to its actual undertaking are worth stating.[3] Central management determines the common ends toward which effort shall be directed and maintains co-ordination between specialized functions or departments. Therefore, it is essential to have definite knowledge of the organization and functioning of these top levels of management and to know how authority is delegated, how control is effected, how departmental or divisional points of view are harmonized, how results are measured, how extravagant practices are corrected, and how waste is eliminated. Chief executives themselves are generally aware of the many problems of co-ordination and control which constantly beset them. However, experience has shown that many times expansions in management organizations are the result of immediate necessity, and accordingly the organization planning goes no further than to solve the problem currently in hand. It was with this situation in mind that one of the leading executives of the Pacific Coast suggested, in the spring of 1939, that the Stanford Graduate School of Business undertake a study of this type. It was proposed to ascertain the general pattern of present-day management; then to make the fruits of such research available to business executives as a guide in planning for future expansion or in gradually revamping their present organizations along more effective lines. The scope of the study was confined to the problems and practices of top management, a field which hitherto had been little explored in the manner of this undertaking. Thirty-one nationally known companies representing diversified industrial enterprises, with a reputation for progressive and enlightened management, were chosen to co-operate in the study. The field work for the collection of the needed factual data required over seven months, with an additional six months to analyze and co-ordinate the vast amount of material obtained and to write up the findings.

RESPONSIBILITIES OF TOP MANAGEMENT

In his foreword Mr. Davies refers to the obvious value of such a study "to those who are actively concerned with the problem of the organization of the management." He then suggests a broader interest. "Beyond this let us hope it may prove generally stimulating to creative thought and excite a deeper and more critical interest in this vitally important subject." The report should do even more than that. It is an impressive statement and tabulation of the vast area included in the administrative problem. No one can read it and fail to be awed at the range of problems for which top management is responsible and to meet which it must plan, organize, and execute. All who are interested in, or aspire to, administrative responsibilities can read here the array of problems as to which a successful manager must either himself be competent or, more commonly, have competent assistance. If the average citizen had even a slight recognition of what good management really means, he would have both more patience with and respect for those men battling to convert and expand our industrial plant to the production of the vast military supplies and matériel required to carry us to victory.

The investigators have divided their book into three parts plus an appendix which is really an important section of their report. The first section is primarily a brief statement of summary and conclusions. In one important respect, however, the section goes beyond mere summary. It includes the authors' definition of what constitutes top management and their concept of its responsibilities.

Top management includes three groups of executives. These are (*a*) the board of directors, (*b*) general management, consisting of those

[1] One of a series of reviews of current economic literature affecting engineering prepared by members of the department of economics and social science, Massachusetts Institute of Technology, at the request of the Management Division of The American Society of Mechanical Engineers. Opinions expressed are those of the reviewer.

[2] "Top Management Organization and Control," by Paul E. Holden, Lounsbury S. Fish, and Hubert L. Smith, Stanford University Press, 1941.

[3] The remainder of this paragraph is a condensation (largely quoted) of parts of the preface by J. Hugh Jackson, dean, Graduate School of Business, Stanford University.

executives who are concerned with the business as a whole, and (*c*) divisional management, comprising those executives who are directly responsible for the major departments, divisions, or subsidiaries of the company. Upon the vision, farsightedness, and resourcefulness of this small top group largely depends the success of an enterprise.

The primary responsibilities of top management are to provide:

Farsighted planning and clarification of objectives, visualizing the needs of the business and determining its most advantageous future course.

A sound plan of organization, enabling all of its parts, individually and collectively, to function most effectively in reaching the common objectives.

Fully qualified personnel in all key positions, insuring each individual's proper contribution to the whole program.

Effective means of control, permitting top executives to delegate wide responsibility and authority, thereby freeing themselves of administrative detail in order to concentrate on broad planning and direction.

OBJECTIVES OF THE INVESTIGATION

The objectives of the investigation were limited to detailed consideration of but two of the broad responsibilities of top management—organization and control. These are the subject topics of the latter two parts (and major portion) of the report Emphasis is placed in the summary, however, upon the great need for an adequate approach to these responsibilities in order to release time and effort for planning and consideration of objectives. A major conclusion of the study was the great need for more adequate planning and clarification of objectives, both near-term and long-range. "Top executives are too preoccupied with matters of a current nature to concentrate upon the future needs of the business. In addition, they often fail to stimulate and utilize the best thought and assistance of their organizations in formulating sound plans, policies, and objectives.

"Top executives, no matter how competent, cannot function to full effectiveness without a sound plan of organization. A well-conceived, long-range organization program permits changes to be made in the right direction as opportunities arise. In the absence of such a plan, changes must be made on the basis of expediency, organization errors are often perpetuated, and fundamental improvements are seldom realized . . . . Organization charts should . . . . be supplemented by written specifications defining the essential requirements of each level of management, each department, each committee, and each key job or group of similar jobs. Only by a thorough understanding of their respective parts in the whole management picture are individual executives and agencies able to devote their full energies to effective discharge of their proper functions, avoiding duplication of effort, friction, and working at cross purposes which result from lack of organization clarification."

THREE ZONES OF TOP MANAGEMENT

There are three distinct zones of top management. These differ not only as to function but also as the attitude, experience, and background of the individuals responsible. The "trustee function" is the exclusive province of the board of directors, whose point of view must be identical with the stockholders'.[4] In filling this function[5] the directors "represent, safeguard, and further the stockholders' interests, determine the basic policies and the general course of the business, appraise the adequacy of over-all results, and in general protect and make the most effective use of the company's assets."[5] The general-management zone covers the active direction of the business as a whole, including determination of objectives, of operating policies, and of results. The divisional- or departmental-management level embraces the topmost group of executives responsible primarily for a particular division of the company rather than for the whole company.

Although four plans are in use, there is a tendency among large companies, evidenced by adoption in one fourth of the companies investigated and particularly in those which have devoted the most attention to organization planning, to delegate the general-management function to a full-time group or council of general executives. In the other companies the zone was the responsibility of (*a*) the chief executive (who may call upon his fellow officers for advice), (*b*) the chief executive and a designated council of divisional or departmental executives, or (*c*) a managing board of directors (a few cases only). Obviously, size has something to do with the plan adopted, but the authors point out the obvious advantages which accrue when a small group of executives divorced from the problems and administrative routine of divisional management can devote their full time and energies to the broad planning, direction, and co-ordination so vital to the success of the business as a whole.

In the third zone, that of divisional management, are to be found the active direction and management of the respective parts or divisions of the company. "These parts may be operating departments, such as manufacturing and marketing, or staff departments, product divisions, regional divisions, or subsidiary companies . . . . General management, whether it consists of the president or a full-time management group of general executives, should keep itself free of divisional detail, concentrating its full time and energy upon the larger problems of over-all direction and control. Divisional executives should be expected to handle their strictly divisional problems without burdening their principals, assuming as nearly full proprietary responsibility and accountability for the successful conduct of divisional operations as is consistent with the need for over-all co-ordination and control."

ORGANIZATION OPERATING PLANS

Operating organization takes many forms among the thirty-one companies but falls into three general patterns. The traditional approach is functional. Under this plan manufacturing, sales, and finance are carefully segregated, and in each area a single executive leads the necessary departmental organization to accomplish results. A second arrangement, and one particularly adapted to decentralization of management, approaches the problem from a product standpoint and places a single executive in charge of a product or product group with full responsibility for all functions as they relate to his product. The third plan is similar, but instead of products uses regions as the basis for division of responsibility. The investigators found a need for more careful attention to the use of staff departments and committees. "As the managerial process grows in complexity, the time, ability, and comprehension of single executives become increasingly inadequate and must be supplemented by staff agencies able to furnish specialized assistance and advice. An adequate staff organization, designed to take full advantage of specialized knowledge, concentrated

[4] There are many who might disagree with this rather extreme position. Should not the directors "represent" the owners in the sense that the directors' considered judgment is to be followed for the long-term good of the owners as opposed to a present narrowly short-term selfishness which in fact is the attitude of the majority of the individual owners? True, this may mean the loss of the directors' jobs, but is it not a better type of trusteeship? Contrast the statement of the authors. "The point of view of the board of directors must . . . be identical with that of the stockholders. At all meetings of the board this viewpoint should outweigh any other consideration."

[5] The functions, composition, organization, and procedures of the board of directors as operating in the group of companies investigated are discussed in some detail in an appendix to the main report. Executives who have to deal with their board will find of particular interest an outline of some twenty major functions held by the directors and of an actual statement taken from an organization manual defining "matters requiring action by the board of directors."

attention, unified effort, and definite accountability for results within its appropriate fields, can go a long way toward relieving the burden and increasing the effectiveness of management." In actual practice the number of staff departments in a single company ran from eight to twenty-five. All told, more than fifty different staff agencies were found, divided among control, service, co-ordinative, and advisory departments.

VALUES OF COMMITTEES CONTROVERSIAL

The value of committees proved to be a controversial question. Nevertheless, over seventy-five different committees were found in use and studied. The conclusion of the investigators is that they serve a real function, without overlap in purpose or objective between committees properly established and regular staff departments. Whereas the latter are used to provide specialized and expert advice in particular fields, "committees should be created only when it is desired to obtain the coordinated best judgment of a particular group." Committees are an effective device (1) to co-ordinate activities, (2) to provide well-considered recommendations on matters of company-wide concern, and (3) to provide group judgment in lieu of individual judgment on such matters as salaries, appropriations, or promotions. They are also an excellent training medium for the members composing them.

CONTROL PRACTICES

The second important objective of the investigation was a study of control practices. The results are given in the third and longest section of the report.

Whereas the section on organization approaches the subject from the angle of principles or plans of organization, the discussion of control practices is broken down by areas subject to control. There is only a brief (two pages) introductory discussion of the basic process of control. This is, however, fundamental. The authors point out the need for control devices as a necessity to relieve management of an overburdening of detail—largely of approvals of acts of others. Control itself must rest on the satisfactory treatment of three elements. These apply in whatever field control is attempted. There must first of all be a clear recognition of the objectives of the activity. Next must come definition of individual responsibility, decision as to how and when the function is to be carried on, and determination of reasonable standards as to what constitutes good performance. Finally, control is based on an appraisal of how well the job has been done.[6]

The investigation of control practices covered a wide range of activities and uncovered much interesting material. The emphasis given by the order of discussion is significant and important. Of sixteen control problems discussed, the first four, in order, were control over policies, control over rate of operation, control over organization, and control over quality of key personnel. Policies, organization, and key personnel come close to the essence of management. Yet, too many managers fail to recognize them as areas subject to continuous control.

Even a mere tabulation of the remaining control problems receiving specific treatment is interesting in its range. They are:

- Wages
- Salaries
- Costs
- Methods and man power
- Capital expenditures
- Service department effort
- Line of products
- Research and development
- External relations
- Foreign operations
- Demands upon executive time
- Over-all performance.

The practices uncovered and reported will stimulate the imagination of anyone concerned with management. Among ideas drawn from so large a group of successful companies it is impossible that there should fail to be something new for any student. If nothing more is accomplished than a check to insure completeness of control coverage, there should be a great gain.

HUMAN RELATIONSHIPS ARE INVOLVED

Here then is a volume of great practical value to the active manager. In spite of this, the very value which it has requires a warning. The authors specifically give this warning in their introduction, but it is almost sure to be forgotten by all but those with considerable experience in the field of management.

Organization is not a mere matter of charts and nicely planned allocation of responsibilities. Nor is control solely practice and procedure. Both are problems of men and human relationships. In this simple fact can be found the explanation as to why some organizations and control plans apparently meeting all the rules fail and why others succeed in the face of technical inadequacies. This reviewer has seen cost-control plans work out with great success when analysis shows the plans to be based on completely unreal and unscientific assumptions as to the reactions of costs to varying conditions. The success arose from a co-operation and confidence among men that inspired them to overcome the technical errors. On the other hand, elaborately planned procedures have failed because they do not have the necessary confidence and are not used by the only ones who can actually control.

Organization is dynamic, not static. Seldom is it possible to find a group of men equipped to fill each spot in the chart. Even if this can be done once, each promotion or replacement brings new problems and usually forces a reallocation of duties—to the detriment of the chart, which must be looked upon as a long-term ideal. Some men will fail to accept all responsibility offered to them. Others will reach out to enlarge their jobs or to create new ones not included in the plan. The organization planner frequently cannot inflate the first to fill their assignments, nor does he wish to confine the expanding ability of the others.

Organization plans and charts and control procedures are management tools. They must be designed to meet the requirements of the job. Perhaps the greatest single requirement is the personalities and personal equipments of the men who are to use them—and that means management itself. Some men like figure reports; others like bar charts or pie charts. Both can be used to convey the same information, and it is good sense to use the one which the particular man likes best. Part of the job is to find the device which is most helpful. Another part is a willingness to change the tool whenever a better one is found or a new personality must use it.

These comments do not constitute a criticism of the report of the investigators. They are an elaboration of a self-imposed limitation by the investigators. Their objective was to show what tools are available to management. Now management's job is to find and use the ones best suited to its needs. It is only in those cases where no need is recognized that there is any final limitation; and that is a sad one indeed, for it is a self-confessed limitation on the competence of the management in question. Certainly this report can provide a wealth of assistance to those who are seeking to do a better job.

[6] An additional implied element, which might well have been stated, is a necessary reporting of results as a basis for appraisal. Many companies fail in this vital area.

Some Aspects of INDUSTRIAL LUBRICATION

By W. J. HUND, R. G. LARSEN, OTTO BEECK, AND HAROLD G. VESPER

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ONE of the primary functions of a lubricant is to reduce the friction between moving metal parts and thereby to reduce wear of these parts. Reasons for the use of mineral oil for the purpose are manifold, a few of which are proper viscosity and volatility, chemical inertness, and economy.

For most industrial equipment the most important property for a lubricant to possess is sufficient viscosity to insure that hydrodynamic lubrication prevails at all times. The chief insurance of good lubrication for bearings is that the design be such that the oil trapped or wedged between the moving parts cannot escape and that enough of it is trapped to separate the moving parts completely and not permit them to touch even under shock-load conditions. The viscosity of the oil as well as the velocity of motion are important factors in maintaining a thick film.

When the surfaces or projecting asperities on the surfaces of moving parts are permitted to make contact, which generally occurs under high pressures, or low sliding velocities, then wear begins to take place. At that instant the oil film is extremely thin, and it is what happens in this thin film and on the contacting surface that provides the real problem of "wear." Here viscosity is not considered to be the most important property of an oil, for many engineers and operators speak of "oiliness" and "film strength" to designate mysterious properties of oils which permit them to reduce wear under these severe conditions of thin-film or boundary lubrication. However, it is unsatisfactory to ascribe such differences, if they do exist, to a vague and unknown property; rather, it is important to understand more of the mechanism of boundary lubrication and the effect of various chemical factors.

THE MECHANISM OF BOUNDARY LUBRICATION

A characteristic of lubrication under boundary conditions is that the coefficient of friction is practically independent of both viscosity and sliding velocity. This is illustrated in Fig. 1 which shows the typical relation between coefficient of friction f and ZN/P (the product of viscosity and velocity divided by the pressure). The region of hydrodynamic lubrication is that to the right of the minimum, and the region of true boundary lubrication is the short horizontal portion close to the f axis. Between these is a transition region, indicated by dashes, which may be called one of quasi-hydrodynamic or partial boundary lubrication.

Different oils have different coefficients of boundary friction, and those with low values are said to have more "oiliness." Certain substances having long hydrocarbon chains with polar groups on the end are effective in reducing coefficient of friction when added to an oil such as medicinal oil which is free of these materials. Chemically, it would seem that reduction of coefficient of friction must be due to adsorption of the long-chain polar compounds on the rubbing surfaces, although the mechanism of this action has not been understood.

The work in our laboratories on this subject was described recently by Beeck, Givens, Smith, and Williams[1] and was performed with a machine utilizing the four-ball bearing as illustrated in Figs. 2 and 3. The first is a general view of the machine; the second is a diagram of the bearing. This is a modification of the Boerlage four-ball top[2] designed to run continuously if desired so that wear as well as friction measurements could be made. If the coefficient of friction were constant, it could be calculated from the time necessary for the top to stop spinning after receiving a certain initial angular velocity. Careful analysis showed however that the coefficient of friction is not constant over the whole velocity range, and it must be calculated from the instantaneous values of velocity throughout the spin of the top. When the coefficient of friction is plotted against velocity, curves of the type shown in Fig. 4 are obtained.

The curve for white oil alone is typical of the high and erratic values obtained with this material; such behavior results from the fact that for white oil no definite state of lubrication is established under these conditions of velocity and pressure. The curves for oleic acid and for white oil plus oleic acid are characteristic of those for materials containing long-chain polar compounds. Even though the entire operation is in the region of boundary lubrication, where, as explained, it has been assumed that the coefficient of friction is a constant, it will be noted that at velocities above certain critical values, which are quite reproducible, the coefficient of friction drops off rapidly and that below these values it is constant as expected. Thus the true region of boundary lubrication is that relatively narrow region within which friction is actually independent of viscosity.

The low coefficient of friction obtained at relatively high velocities must be caused by a state of quasi-hydrodynamic lubrication, or what may be called a "wedging effect," due to a surface activity of the oil and the availability of a sufficient quantity to be wedged. In agreement with this expectation, it was found that monomolecular layers of these polar materials did not exhibit this effect, but that it does occur with flood lubrication using these polar substances. Also it was shown that viscosity had little effect, hence this behavior does not appear to be associated with the properties of the lubricant in bulk.

Using the electron diffraction camera, it was found in fact that all substances showing the wedging effect have a highly oriented surface structure. The lowest critical velocities at which the effect first appears are obtained with the most highly oriented films, the hydrocarbon chains extending out either perpendicular or at an angle. These oriented materials may even be hydrocarbons themselves although such films are less stable under heat. These results were confirmed by the fact that at higher temperatures in the four-ball test, only the tem-

Based on an address by W. J. Hund, before the San Francisco Section of THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS, San Francisco, Calif., Dec. 4, 1941.

[1] "On the Mechanism of Boundary Lubrication," by O. Beeck, J. W. Givens, A. E. Smith, and E. C. Williams, Proceedings of the Royal Society of London, series A, vol. 177, 1940, pp. 90–118.

[2] "Four-Ball Top for Testing Boundary Lubricating Properties of Oils Under High Mean Pressures," by G. D. Boerlage and H. Blok, *Engineering*, vol. 144, July 2, 1937, pp. 1–2.

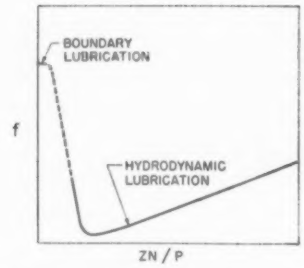


FIG. 1 COEFFICIENT OF FRICTION IN REGIONS OF BOUNDARY AND HYDRODYNAMIC LUBRICATION

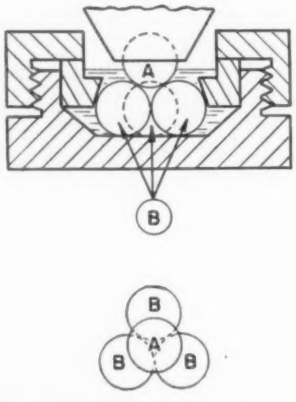


FIG. 3 (*right*) FOUR-BALL BEARING

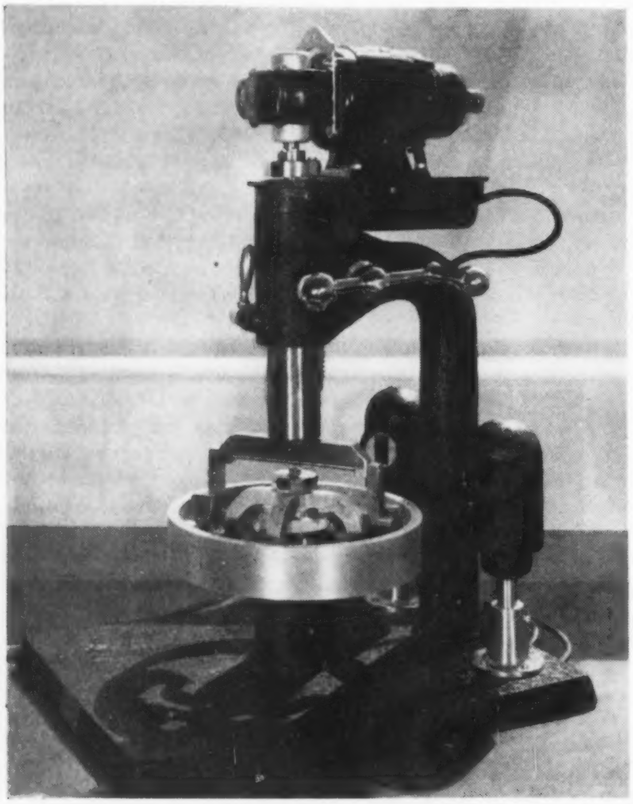


FIG. 2 FOUR-BALL TOP
(Serving also as wear apparatus.)

perature-stable polar films have low critical velocities.

It was found also that above the critical velocity the electrical resistance between the balls is very high, 10,000 ohms or more, but that below the critical velocity it drops to 250 ohms or less. This indicates that the observed critical velocity is a point at which physical separation of the bearing surfaces is markedly increased. This is in line with the concept of lubricant wedging.

It should be mentioned that a considerable degree of polish must be maintained for the wedging effect to occur.

WEAR PREVENTION: ROLE OF CHEMICAL POLISHING AGENTS

It is an observed fact that reduction of the coefficient of boundary friction does not necessarily cause a reduction in wear. The reason for this is obvious when it is considered that wear takes place at isolated spots, which are small compared with the whole surface, and that a momentarily high coefficient of friction at this point does not affect the over-all friction.

Bowden has shown that the most carefully machined parts have a microscopic roughness and that the applied load is not uniformly distributed over the complete surface, but is carried by a few high spots, perhaps 1/10,000 of the apparent area. At these high spots under boundary lubrication conditions the enormous pressures produce excessively high temperatures resulting in welding and tear and a general roughening of the surfaces leading to higher and higher temperatures of the bulk of the metal and ultimate seizure and breakdown.[3] All of the oil save the tightly held monomolecular layer would be squeezed out, and adsorbed layers of polar molecules could not possibly give protection since such films would be destroyed instantly because of the high temperatures and pressures. It is clear that if the load were evenly distributed over the entire area, then much less severe conditions would prevail. Accordingly, if the surfaces were highly polished and could remain so, then the opportunity for polar agents to be effective is much greater.

In studying this possibility, the extent of wear with the four-ball machine was measured in three ways. First was to measure the diameter of the scar worn into the lower ball, which under a standard test measures the wear permitted. Such a scar is shown in Fig. 5. The second method was by colorimetric determination of the iron content of the oil held in the cup. The third was by measuring the time to wear through a plating of copper or other metal on the steel balls.

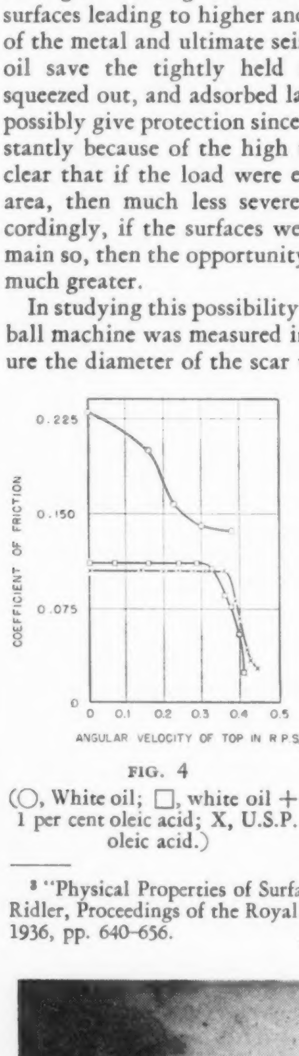


FIG. 4
(○, White oil; □, white oil + 1 per cent oleic acid; X, U.S.P. oleic acid.)

Using these methods we have found a large group of chemicals, related to phosphorus, which are capable of giving very low wear by producing and maintaining the rubbing surfaces in a polished

[3] "Physical Properties of Surfaces," by F. P. Bowden and K. E. W. Ridler, Proceedings of the Royal Society of London, series A, vol. 154, 1936, pp. 640–656.

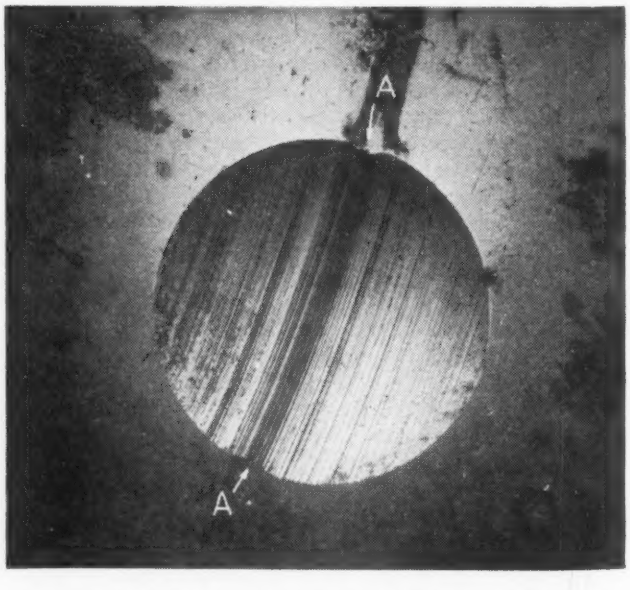
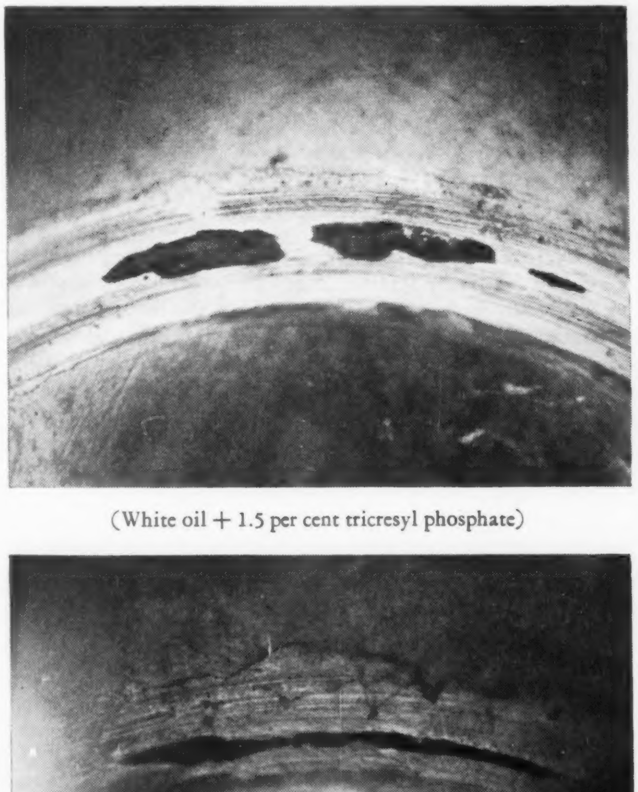


FIG. 5 WEAR SCAR OBTAINED ON FOUR-BALL TESTER

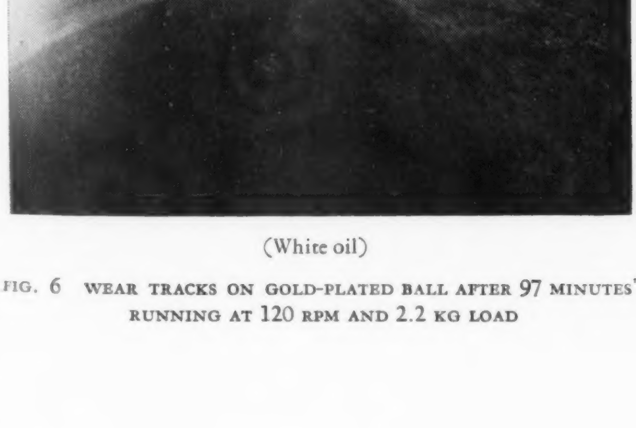
condition. The best known example of this group of substances is tricresyl phosphate, with which most of the experiments were performed.

It was shown that this material acts by a corrosive rather than a protective action. Thus the high spots, which are hot, react very rapidly with the wear reducing agent to form a metal phosphide. The metal phosphide alloys with the surface and lowers its melting point very considerably, thus permitting the metal to flow into the valleys, resulting in a highly polished surface. The chemical action is temperature-selective so that when there are no high pressures and temperatures there is no chemical action.

To check these ideas, a large number of substances were tried, such as arsenic and antimony compounds, which are also capable of alloying with iron; all were found to be more or less effective. To test the theory in another way a phosphorus compound was used with a tin surface. Now phosphorus alloys with tin to raise the melting point, and accordingly the smoothing action should not take place. The results were as expected—the phosphorus compound was found to actually increase the wear on a tin surface by a factor of four. On the other hand phosphorus gives a low-melting alloy with copper, and accordingly the phosphorus compound should reduce wear on a copper surface. This was found to be the case. Also, a metal such as gold which does not alloy at all with phosphorus should show the same rate of wear whether or not a phosphorus compound is present. This also proved to be the case as shown in Fig. 6. The upper wear track, through a gold plating of definite thickness, was obtained when lubricating with white oil containing tricresyl phosphate, and the similar lower wear track was obtained, in the same time, with white oil alone.



(White oil + 1.5 per cent tricresyl phosphate)



(White oil)

FIG. 6 WEAR TRACKS ON GOLD-PLATED BALL AFTER 97 MINUTES' RUNNING AT 120 RPM AND 2.2 KG LOAD

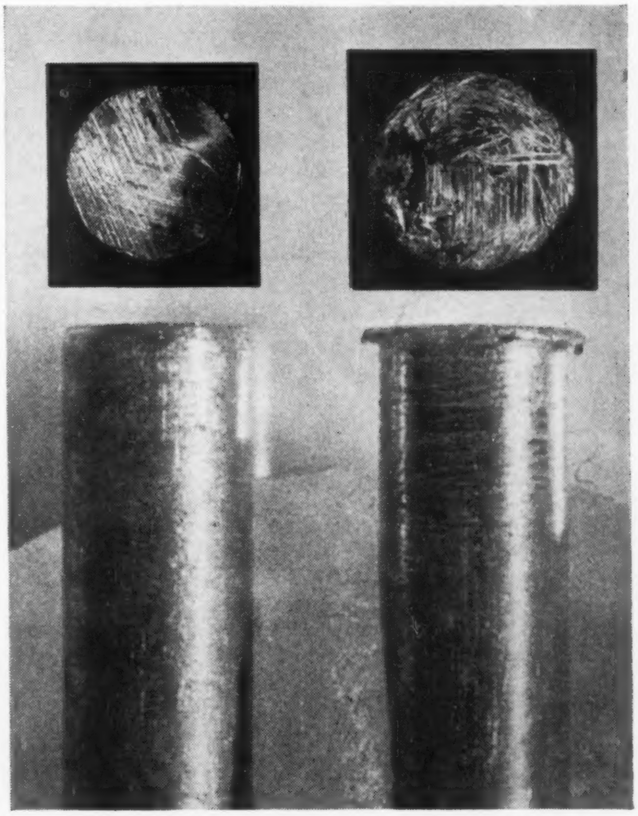


FIG. 7 STEEL PINS SLIDING ON ROTATING STEEL DISK
(*Left*, lubricated with white oil + 1.5 per cent tricresyl phosphate; *right*, lubricated with white oil only.)

The fact that polishing by eutectic formation at the high spots is quite different from the sort of polish produced by pure plastic flow of the metal is illustrated in Fig. 7 which shows the results of sliding a steel pin on a disk with and without the use of tricresyl phosphate. The loss of weight with both pins is identical but, in the case of the pin on the right, lubricated with white oil alone, a great deal of plastic flow has occurred along crystal boundaries and a rather rough unpolished surface is produced. In the case of the oil containing tricresyl phosphate, the temperatures had never gone high enough to cause plastic flow and part of the original machine marks are still present, the other part of the pin having become highly polished.

USE OF POLAR COMPOUNDS WITH TRICRESYL PHOSPHATE

It was earlier stated that polar compounds ("wedging" agents) are useful only when the surfaces are maintained in a polished condition. This led to experiments to see the effect of combining a chemical polishing agent with a polar wedging compound. The data in Table 1 show that the combinations are about twenty times as effective as the polar material alone and about twice as effective as the polishing agent alone.

It should be understood, of course, that these scientific studies of wear prevention were intended to furnish a background of understanding and do not represent the development of any

TABLE 1 WEAR OF COPPER-PLATED BALLS

Material added: Polishing agent	Material added: Wedging compound	Wear-reduction factor
Tricresyl phosphate (1.5%)		5.4
Tricresyl phosphate (1.5%)	+ oleic acid (1.0%)	10.3
	Oleic acid (1.0%)	1.4
Tricresyl phosphate (1.5%)	+ copper oleate (1.0%)	10.3
	Copper oleate (1.0%)	1.1
Tricresyl phosphate (1.5%)	+ stearone (saturated solution)	8.6
	Stearone (saturated solution)	1.4
Tricresyl phosphate (1.5%)	+ mesityl heptadecyl ketone (1.0%)	10.4
Tricresyl phosphate (1.5%)	+ tristearine (1.0%)	14.2
Triphenyl arsine (1.5%)		12.2
Triphenyl arsine (1.5%)	+ oleic acid (1.0%)	2.4
Triphenyl arsine (1.5%)	+ mesityl heptadecyl ketone (1.0%)	17.6

particular commercial oil. Many factors would require evaluation, and extensive practical tests would be needed, before the time could be considered ripe for commercial developments.

EXTREME-PRESSURE AGENTS

It is now possible to compare the action of chemical polishing agents just discussed with that of agents used in extreme-pressure oils. In all cases, equal distribution of the load over the bearing area is essential; thus a high polish is essential. Both E.P. agents and chemical polishing agents will do this, and both do it by chemical attack due to high temperature. Even with the load evenly distributed the minimum load in these bearings may still be too high for maintenance of a stable oil film, and metal-to-metal contact may occur. Since the area of contact is large, seizure under these conditions is catastrophic compared to the seizure at minute points experienced under normal wearing conditions. The distinction between these two types of agent is that the surface left by the chemical polishing agent is apparently in condition to weld with the opposite member, while on the other hand the polishing action of the E.P. agent leaves a surface film such as a sulphide or chloride which does not permit the metals to weld together. Extreme-pressure agents thus protect from breakdown not only by good load distribution but also by film formation. This is further illustrated by the observation that many long-chain acids also corrode surfaces at high temperatures, and thus lead to a type of polishing action, but since an antiwelding film is not formed, their value as extreme-pressure agents is small.

It is interesting to note that if the surfaces are polished mechanically, the maximum load which a mineral oil can stand (film strength) is practically as high as with the oil containing the E.P. agent. In the case of the mineral oil, the polished surface is soon lost, however, and failure occurs. Thus in a Timken machine breakdown occurred with white oil run under normal conditions at 520 kg per sq cm while if the ring was maintained in a polished condition by the use of crocus cloth the ultimate pressure was 3110 kg per sq cm. This closely approaches the value of 3560 kg per sq cm for an E.P. agent.

These ideas show that it is not the "film strength" of adsorbed lubricants but rather the condition of the bearing surface that gives high load-bearing capacity.

BEARING FINISH

A word of caution should be given with regard to interpretation of surface finish of machined parts. On highly loaded parts equal load distribution is essential but it is also necessary that the surface contain oil channels or reservoirs to help support the load as well as to supply oil to replace that squeezed out because of the high pressure. The essential thought here, as shown in Fig. 8, is that these channels should be *below* a plateau and not be formed between protuberances. With this plateau there is no chance for interlocking of contacting surfaces which would result in tearing, and the load may still be distributed over what may be called the major apparent bearing area.

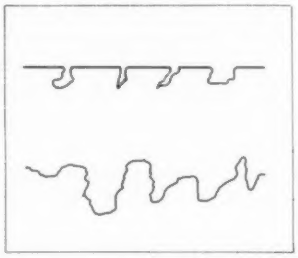


FIG. 8 TYPES OF SURFACES

Incidentally it is obvious from the foregoing comparison that a simple statement of finish as so many microinches does not truly characterize the type of surface finish.

EFFECT OF PRESSURE ON VISCOSITY

The average motorist perhaps, as well as the average engineer, considers a relatively small change of viscosity with temperature to be an important criterion of oil quality. From the standpoint of lubrication, however, the change of viscosity with pressure may be more important, particularly when the oil is used in machinery operating at a pressure of several thousand psi. Under such conditions, unless viscosity is sufficiently high, the thickness of the lubricant film is reduced to the point where projecting asperities may easily penetrate. As shown by Everett[4] and more recently discussed by Givens,[5] the increase in viscosity with pressure, however, is considerable; thus at 20,000 psi the viscosity may be as much as 200 times as great as at atmospheric pressure. It so happens that oils which decrease more rapidly in viscosity with increase of temperature also increase more rapidly in viscosity with increase of pres-

[4] "High-Pressure Viscosity as Explanation of Apparent Oiliness," by H. A. Everett, *S.A.E. Journal*, vol. 41, 1937, pp. 531–537.

[5] "Effect of Pressure on Viscosity in Relation to Lubrication," by J. W. Givens, *Industrial and Engineering Chemistry*, vol. 31, no. 9, September, 1939, pp. 1135–1138.

TABLE 2 VISCOSITY CHANGE RESULTING FROM TEMPERATURE AND PRESSURE RISE IN BEARING

	Load, pounds per square inch of projected area	6000	8000	10,000	12,000	14,000	16,000	18,000	20,000
Oil No. 1 (Eastern)[a]	Temp rise, F	1	2	6	9	13	17	23	31
	Viscosity at atm pressure, centipoises	37	34	32	30	28	25	23	19
	Viscosity at bearing pressure	87	127	176	242	320	437	557	677 = 36X
Oil No. 2 (Mid-Continent)[a]	Temp rise, F	5	9	12	15	20	25	34	44
	Viscosity at atm pressure, centipoises	35	32	31	28	26	23	19	15
	Viscosity at bearing pressure	96	138	200	278	405	530	713	914 = 61X
Oil No. 3 (Western)[a]	Temp rise, F	10	15	20	24	31	38	49	64
	Viscosity at atm pressure, centipoises	28	25	22	20	17	14	11.5	9
	Viscosity at bearing pressure	155	245	390	627	872	1380	1670	1850 = 206X

[a] Designates crude-oil source. These oils are not necessarily representative of commercial products from these crudes.

sure. In fact a rough calculation shows that in general an increase of pressure of 200 psi has about the same effect on viscosity as lowering the temperature 1 F.

Table 2 shows that in an actual bearing the change in viscosity due to temperature rise of the bearing is much less than the change in viscosity due to pressure, so that in fact, because of the effect of pressure, the thicker, safer film would be produced from oil No. 3, which showed the greatest tendency to decrease in viscosity with temperature.

TURBINE OILS

The subjects so far mentioned are all problems in nonhydrodynamic lubrication. Some problems arise, however, even where hydrodynamic lubrication can be provided. An example is the lubrication of turbines, where rust, emulsions, and sludges may form.

Early types of turbine oils deposited sludge, which not only interfered with oil flow but also stabilized emulsions with the ever-present water, and these were sometimes so serious as to render separation of the water impossible. In the initial attack of the oil industry on the problem, refining processes were evolved to reduce sludging, but it was soon found that soluble deterioration products, including acids, were equally harmful, since they also increased emulsion difficulties. This led to a concentration of attention upon oxidation stability to the exclusion of other considerations such as the ability of an oil to wet metal surfaces and thus to prevent rusting. This oversight was understandable since the early-type oils either possessed natural antirusting agents or formed them by oxidation; but the manufacturing processes which led to improved sludging and emulsification characteristics left oils without such antirusting (wetting) agents and too stable to form them.

Troublesome rusting in turbines was first experienced about two years ago in the governor mechanism, and more recently even the rusting of gears has occurred. These weaknesses were early recognized and considerable work has been done to produce stable but nonrusting oils.[6]

First it was necessary to develop tests for stability of the oil toward aging and for rusting tendencies. In developing the stability test the effect of catalysts, water, temperature, volatile oxidation products, and the like, all had to be evaluated. In the test as developed, both iron and copper are present as catalysts, together with water, temperature is held at 100 C, and volatile oxidation products are retained as much as possible by refluxing. The test correlates well with practice inasmuch as oils are rated in the same relative order as by their known service records. In the rusting test which was developed the oil is stirred at 75 C, in the presence of 10 per cent of water, for 48 hr. The test correlates better with service than previous tests, which were less severe.

In examining various turbine oils by these tests, nearly all were found deficient either in stability or in antirusting quality. The best oil examined, however, showed a stability in the aging test of over 2000 hours (corresponding to several times this figure in service) and as shown by the corrosion test it completely prevents rusting.

BEARING CORROSION

Another interesting problem in the field of hydrodynamic lubrication, though of more importance in the lubrication of internal-combustion engines than for other types of machinery, is the corrosion of hard bearing alloys such as copper lead, cadmium silver, and cadmium nickel. These are used in high-output engines under conditions of temperature and load which

[6] "Evaluation and Performance of Turbine Oils," by G. H. von Fuchs, N. B. Wilson, and K. R. Edlund, *Industrial and Engineering Chemistry*, Analytical edition, vol. 13, May 15, 1941, pp. 306–312.

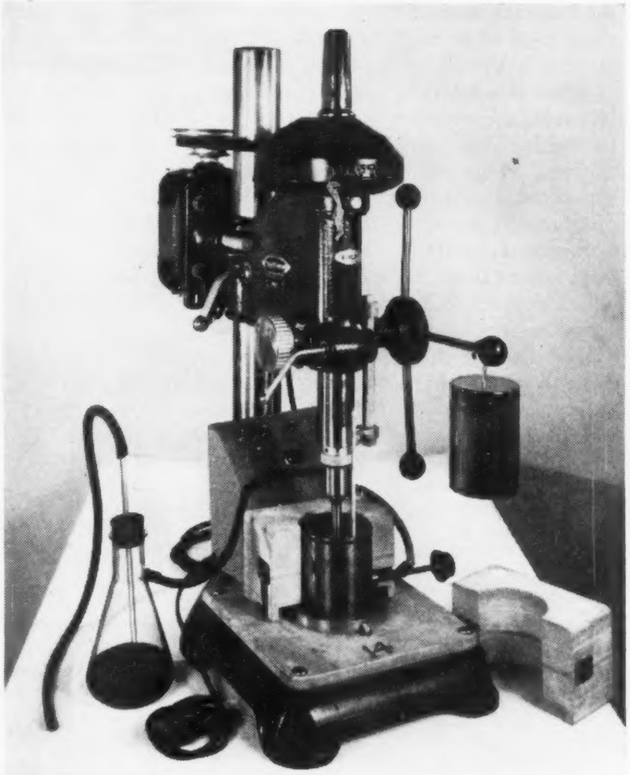


FIG. 9 THRUST-BEARING CORROSION MACHINE

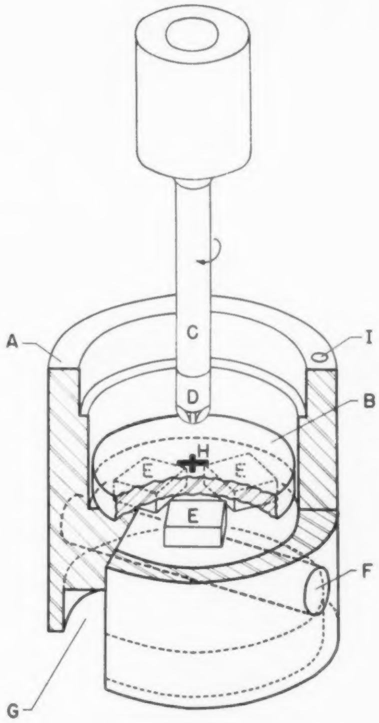


FIG. 10 THRUST-BEARING CORROSION MACHINE—GENERAL CONSTRUCTION

(*A*, steel cup; *B*, hardened steel disk; *C*, driving spindle shank; *D*, fiber tip; *E*, bearing specimen and support; *F*, hole for thermoswitch; *G*, recess for electric heater; *H*, recess to accomodate tip *D; I*, thermometer well.)

are more severe than babbitt will withstand. The attack upon these hard-alloy bearings is especially severe when it is necessary, as in Diesels, to use detergent additives in the oil.

When this difficulty first arose, very little was known as to its cause, nor were there any reasonably effective means of combating it. The first investigations were carried out in actual engines, whose anatomy is so complex that the results of the experiments could not be interpreted with certainty and simplicity. On the other hand, laboratory experiments that were devised to simplify the studies did not successfully imitate the high rate of shear in the oil layers next to the bearing surface, which appears to be an essential condition of the corrosion in actual engines.

Figs. 9 and 10 show a general and a sectional view of the machine developed in our laboratories and recently described by Talley, Larsen, and Webb[7] for study of the various factors that control the appearance and extent of bearing corrosion. To insure hydrodynamic conditions it employs a Kingsbury thrust bearing. The test conditions are ordinarily set so that the corrosiveness of an oil is measured as independently as possible of all other factors; if the effects on corrosion of oxidation, for example, under any particular conditions in the laboratory or the engine are desired, the oil is subjected to those conditions and then examined in the thrust-bearing corrosion machine. It is also possible to alter the test procedure to provide a considerable degree of oxidation during the test if this is desired.

The photomicrographs shown in Fig. 11 are cross sections of copper-lead bearing specimens after test in the machine. Different degrees of corrosion penetration are indicated.

Studies with the machine have shown that temperature is a very important factor in the corrosiveness of an oil; and if the temperature at which the corrosiveness in the test becomes pronounced is lower than the operating temperature of the bearing in service, corrosion difficulties may be expected.

In this brief discussion it has been possible to touch on only a few high lights of the subject of lubrication. In particular the important subject of engine lubrication, an intensive study of which is being made by both lubricant and engine manufacturers, has been almost entirely omitted.

[7] "A Laboratory Machine for Investigating Corrosion of Bearings," by S. K. Talley, R. G. Larsen, and W. A. Webb, presented before the Petroleum Division A.C.S., Atlantic City, N. J., September 8–12, 1941. To appear in *Industrial and Engineering Chemistry*.

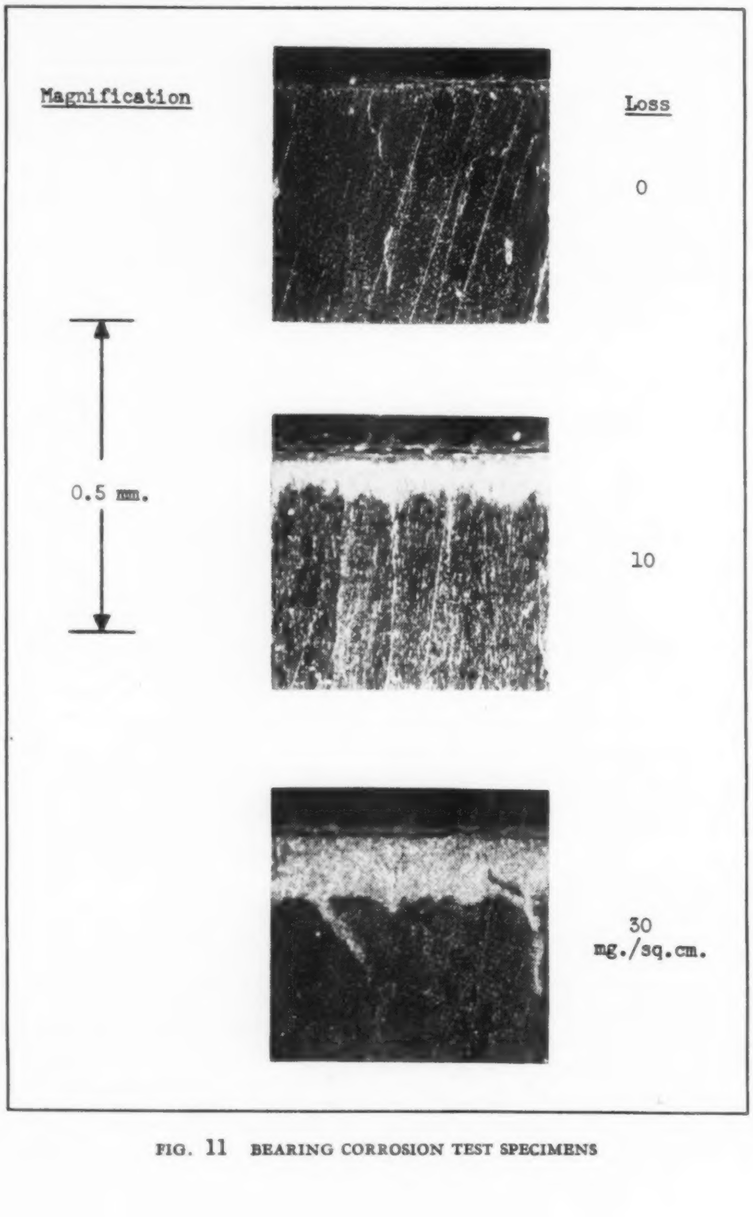


FIG. 11 BEARING CORROSION TEST SPECIMENS

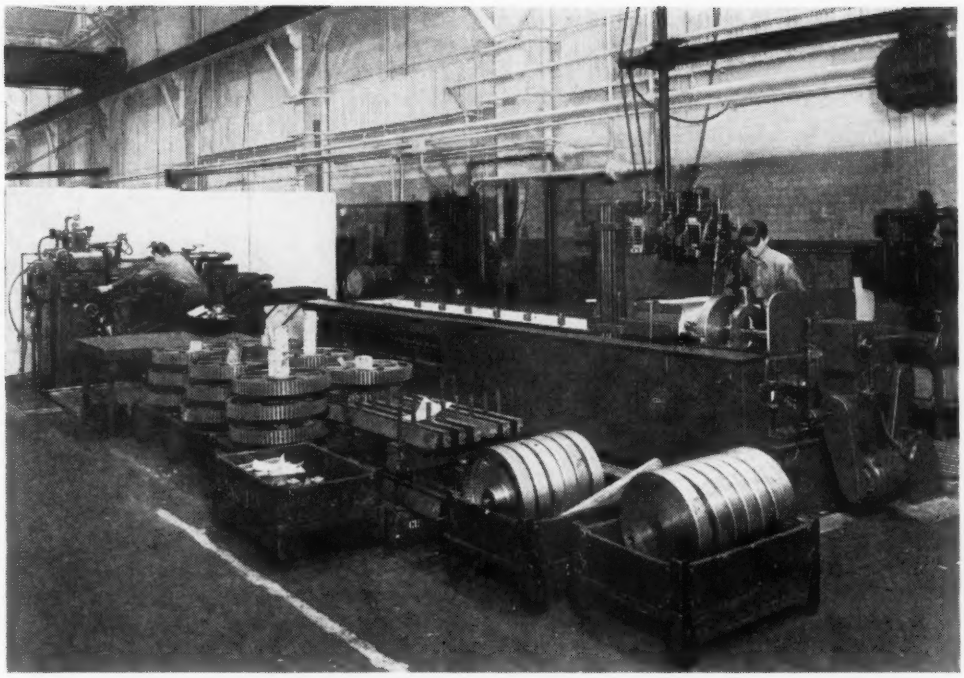


FIG. 1 GENERAL VIEW OF FLAME-HARDENING DEPARTMENT
(LeBlond universal flame-hardening machine in foreground and Fellows gear-hardening machine in background.)

Practical Application of FLAME HARDENING

By A. L. HARTLEY

METALLURGIST, THE R. K. LEBLOND MACHINE TOOL CO., CINCINNATI, OHIO

TO obtain uniform high-quality flame-hardened parts the process must be given the same rigid technical control that is applied to other forms of heat-treatment. It cannot be considered an easy cure-all for every heat-treating difficulty. It must be classified as a new technical process that will help to solve many problems. Although most engineers are familiar with the various methods of flame hardening, it might be well to review briefly some of the fundamentals.

I—FLAME-HARDENING PROCESSES AND EQUIPMENT

SPOT HARDENING

Spot hardening is considered the most elementary form of flame hardening. This method merely consists of holding an oxyacetylene flame or group of flames over a given area and applying the heat for a given definite predetermined period, then quenching.

SPIN HARDENING

Spin hardening is accomplished by arranging a torch or group of torches around the peripheral surface of a part of cylindrical design. The part is revolved at a speed of approximately 1000 surface inches per minute while the flames are applied. Parts heated in this manner are usually removed from the mandrel and quenched. However, other quenching methods are now under consideration for this type of work, especially when the diameters are larger than 12 in.

PROGRESSIVE HARDENING

Progressive flame hardening may be applied to either flat surfaces or cylindrical parts. The flames are passed over the work surface and the quench follows approximately $^5/_8$ in. back of the last row of flames. The quenching medium is usually air, soluble oil, or water.

SPIRAL PROGRESSIVE HARDENING

Spiral progressive flame hardening may be used for hardening shafts 2 in. or larger in diameter. To harden a shaft by this method it is rotated at a peripheral speed of approximately 4 to 6 in. per min. A burner of suitable width is applied. The surface is quenched by a quenching medium which follows approximately $^5/_8$ in. back of the flames. The torch-carrying mechanism is geared to the driving mechanism in such a manner that the burner is advanced the exact width of the flames each revolution of the work. This method produces a fairly satis-

Contributed by the Production Engineering Division and presented at the Semi-Annual Meeting, Cleveland, Ohio, June 8–10, 1942, of The American Society of Mechanical Engineers.

factory part. However, a slightly softer area exists between the spirals.

COMBINATION SPINNING AND PROGRESSIVE HARDENING

Combination of spinning and progressive hardening can be applied on long cylindrical shafts as an alternative to the spiral-progressive method. The burner or burners are grouped around the periphery of a shaft in much the same manner as used for spin hardening. The work is rotated at a speed of approximately 1000 surface inches per minute. The burners are lighted and allowed to dwell for a predetermined time and then moved longitudinally along the work surface. A circular quench head immediately follows the burners. Shafts $^3/_4$ to 6 in. in diameter may be hardened. A very uniform hard case is produced.

PROCESS DEVELOPMENT

To the best of the author's knowledge there is no method of determining the temperature of a part during the flame-hardening operation. However, he has found after extensive experimental work that the temperature control is a very critical factor in obtaining high-quality results.

Since the temperature cannot be measured directly it is essential that the factors on which the final temperatures of the part are dependent be controlled. In analyzing a flame-hardening setup it is found that the temperature is dependent upon the following variables:

1 Type of equipment used, that is, the size of mixer, type of torch, type of burner, size of flame orifice, and spacing of the flames.

2 The oxygen and acetylene pressure.

3 The distance between the work surface and the tip of the burner.

4 The time interval.

(*a*) For spot hardening and spin hardening the time interval is controlled by the number of seconds the flames are applied to the work.

(*b*) For progressive, spiral progressive, and combination spinning and progressive hardening the time factor is controlled by the rate of travel of the flames over the work surface.

5 The design of the parts being hardened.

If all of the foregoing factors are carefully controlled, the temperature to which a given piece of work is heated can be accurately controlled.

The next problem is the proper interpretation of the results obtained by controlling the foregoing factors. It has been found that the best manner of interpreting these results is by use of the microscope.

To make proper use of the microscope it is necessary to have a set of standardized specimens for each material to be flame-hardened. These specimens can be obtained by furnace-hardening a series of small cubes of the given material from a wide range of known temperatures. These quenching temperatures should range from 100 F below the low limit of the recommended hardening range to 100 F above the high limit. The specimens thus obtained can be carefully polished and used as standard structures for the known temperature from which they were quenched.

The five major factors which contribute to the temperature obtained on the surface of a given part must be within certain limits. These limits depend on two factors, namely, practical operating conditions and the thermal conductivity of the material being treated. After they are accurately established by comparing the microstructures obtained by flame hardening to those obtained by furnace hardening, standardized operating data can be readily obtained. Such data can be set up by holding all of the variables except two constant.

For example, in the case of progressive flame hardening, if the following factors are held constant:

1 The type of equipment,
2 The distance between the work surface and the tip of burner,
3 The time interval (in this case the rate of lineal travel at which the torch is traversed along the work surface),
4 The material,

the only variables left are the oxygen and acetylene pressures and the width of the work surface. It is then a comparatively simple matter to work out the proper relationship between those factors. The results can be readily set up in graphic form and used for obtaining the required operating conditions for a wide variety of work.

FLAME-HARDENING EQUIPMENT

After three years of preliminary experimental work in which many jobs were not only tested in the author's plant but were sent out in machines, it was decided that flame hardening had a definite place in machine-tool production. It could readily be seen that it would help to improve the product and to produce this improved product more economically.

As a result of this study a commercial machine was purchased for the purpose of hardening gears up to 12 in. in diameter by the spinning method and a special-design universal flame-hardening machine was made for general machine-tool flame hardening. Now of course it should be clearly understood that no piece of apparatus can be generally universal, so although the machine is called a universal flame-hardening machine, what is meant is a unit that is universal for the products produced in the author's plant.

Machine Requirements

The requirements of such a machine were as follows:

1 It must be suitable for spot-hardening application.

2 It must be suitable for spin-hardening parts from $^3/_4$ in. to 18 in. in diameter.

3 It must be suitable for progressive hardening of parts up to an over-all length of 18 ft and an over-all width of 34 in. The design must be such that a surface 15 ft long can be hardened. The machine must have sufficient capacity to allow a surface 20 in. wide to be hardened in one pass, or provide for the hardening of at least five surfaces simultaneously.

4 It must be suitable for progressive hardening of cylindrical parts up to at least 24 in. in diameter.

5 It must be suitable for spiral-hardening a shaft up to 12 ft in length.

6 It must be suitable for combination hardening of shafts up to 12 ft in length.

Design Features

To obtain such a machine it was necessary to incorporate the following design features:

1 Spindle speeds ranging from 0.032 rpm to 350 rpm.

2 Carriage travel ranging from 3 in. per min to 20 in. per min.

3 Individual oxygen and acetylene regulators for each burner.

4 Ample tank capacity for coolant.

5 Automatic timing mechanism.

6 Flush quenching.

7 Suitable attachments, including leveling devices, steady rests, chucks, etc.

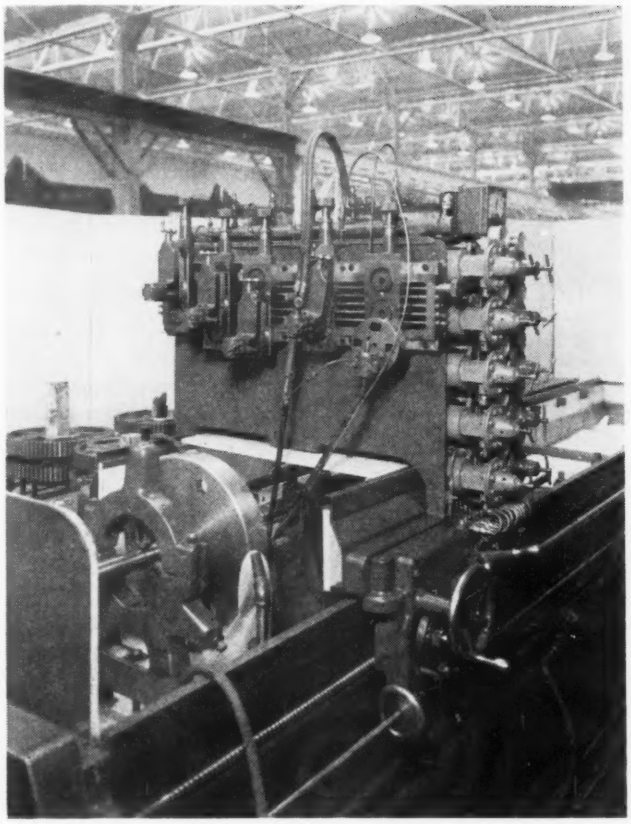


FIG. 2 CLOSE-UP OF CARRIAGE AND APRON
(Note that each torch has individual pair of regulators.)

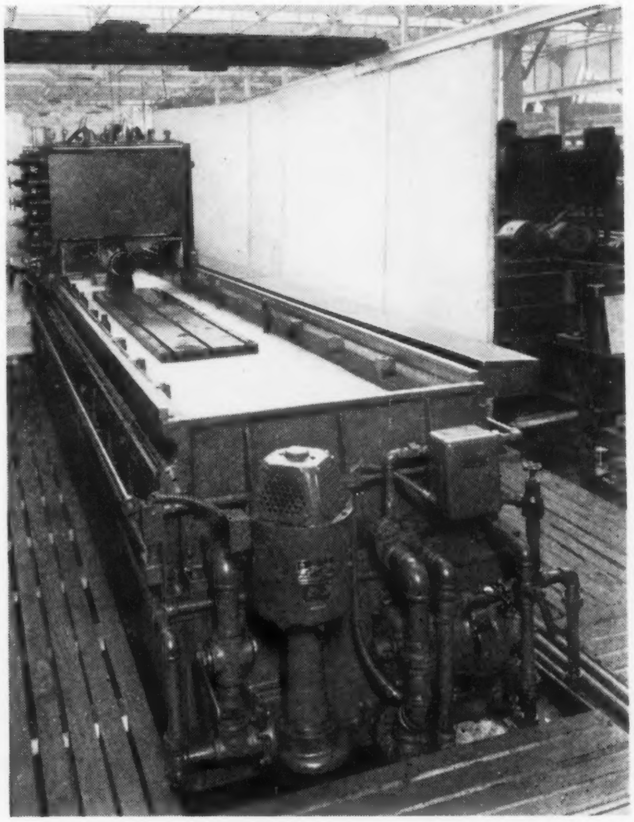


FIG. 3 SHOWS PUMP END OF MACHINE
(Top tank drains into lower one.)

Fig. 1 is a general view of the flame-hardening department as it stands at the present time. The large machine in the foreground is the LeBlond design universal flame-hardening machine. The unit in the background is the Fellows gear-hardening machine. The LeBlond machine has capacity to take a part 19 ft long and has a travel of 15 ft 11 in. Parts up to 34 in. in diameter can be set between centers.

The headstock and driving gear train are clearly shown at the extreme right of this illustration. The small generator that extends from the drive shaft operates a tachometer which is set in clear view of the operator.

The carriage is mounted on antifriction bearings which ride on the side rails. It is equipped with five crossheads which are similar in design to an engine-lathe compound rest so that they can be swiveled to any desired angle. The machine has capacity to harden the flat surface of a part up to 20 in. in width.

Fig. 2 is a close-up of the carriage and apron. From this view it can be clearly seen that each torch has an individual pair of regulators. This feature was deemed advisable because in many cases of progressive hardening it is necessary to operate burners of various widths at different pressures on a single surface.

It may be observed that the carriage is driven by a lead screw which is connected to the headstock unit through a series of pickoff gears. This makes it possible to obtain any desired relationship between spindle speed and rate of lineal travel. A mechanical timing device is incorporated in the design of the apron so that any amount of dwell can be readily predetermined and the use of stop-watch timing is not necessary. The mechanism of the carriage is of such a nature that this mechanical timer can be used even though the carriage is clamped in the stationary position for either spinning or spot hardening. A small handwheel connected to a rheostat is conveniently located so that the operator can accurately adjust the motor speed without leaving the operating position.

The pump end of the machine is shown in Fig. 3. Side rails are mounted on a large bottom tank, a construction which makes it possible to drain the contents of the top tank into the bottom tank.

The large centrifugal pump on the left is used for pumping the coolant from the lower tank to the upper tank. It may also be used to circulate the coolant when large parts are being hardened.

The small pump unit at the right is used for circulating the quench medium to the burner. The electrical control box just above this pump on the left-hand side actuates a solenoid valve which permits flush-quenching at any desired point on the work. This is especially useful in supplying an extra amount of quench just after the torches are extinguished.

Safety Precautions

In developing this equipment every safety precaution possible was taken in its design. All of the gas lines are equipped with check valves and, in addition, a hydraulic flash-back arrester is mounted on the carriage just ahead of the flexible hose on the acetylene line. With these precautions there is practically no possibility that a backflash from any of the torches will get into the large supply hose. However, since there is a possibility that some accident could cause one of the supply hoses to rupture, the main supply line is equipped with a minimum-pressure automatic shutoff valve. If for any reason either the oxygen or acetylene hose should be broken, the gas supply to the entire unit would be instantly shut off.

II—PRACTICAL APPLICATION OF FLAME HARDENING

SPOT HARDENING

Fig. 4 shows a spot-hardening operation on a spindle-nose collar spanner-wrench slot. In hardening a part of this type a special water-cooled plate-type burner head is used. Flames are applied for a given predetermined time and then the part is quenched by the use of the solenoid-operated flush-quench mechanism previously described.

SPIN HARDENING

Fig. 5 shows a typical setup for hardening a 4-pitch gear, 11 in. in diameter, by the spin-hardening method. The torches are grouped around the periphery of this part. The part is revolved and the flames applied. After the desired temperature has been reached the part is removed from the spindle and quenched in an oil bath in the same manner used for quenching a furnace-hardened gear.

Fig. 6 shows a few of the gears which are regularly hardened on a production basis by the spin-hardening method. Although most of these are comparatively simple jobs, a few items are of special interest.

The large ring gear was formerly manufactured by furnace-hardening and grinding the teeth for accuracy. It is now fabricated by shaving the teeth, flame hardening, and lapping. It has been found that the results are equally as good as those obtained by the former method which was much more costly. The other large gear is approximately 11 in. in diameter. Numerous runout tests have shown that the runout is in no way affected by the flame-hardening operation, whereas by furnace hardening there was usually an appreciable amount of distortion.

The pinion shaft illustrated in Fig. 7 is an example of a part that can be flame-hardened on the universal flame-hardening machine. This part is heated by the two burners. The driving mechanism consists of an air-operated universal chuck. After the part has been heated for the proper period the spindle is stopped and the part is removed from the machine. It is then quenched in an oil bath in the same manner that would be used if it had been heated by the conventional furnace-hardening method. This type of heat-treating causes no distortion and thus eliminates the necessity of straightening the part after the hardening operation.

Another type of part which is hardened on a production basis by the spin-hardening method is illustrated in Fig. 8. The only portion of this part which requires hardening is the positive tooth clutch. The teeth of this clutch are hardened by the use of a special burner. The part is revolved and the flames applied directly to its face. After the flames are applied for a predetermined time they are automatically cut off and the part is quenched. The actual heating time for this particular part was 5 sec.

Although there is a definite advantage in the time interval required to harden the part by the flame-hardening method, the main advantage is the fact that there is no necessity of grinding the hole. There are also many parts similar in design to the one illustrated which require taper-pin holes to be drilled in assembly. The machining problem on that type of part is greatly simplified by the spin-hardening method of heat-treatment.

At present 135 jobs are routed for spin flame hardening through the author's plant and more than 35,000 parts have been hardened.

PROGRESSIVE FLAME HARDENING

Gears ranging from 4 diametral pitch to 1 diametral pitch are probably the most universal parts hardened by the progressive flame-hardening method. The setup shown in Fig. 9 is typical of this application. Two gears are set tightly together and two special gear-hardening burners are applied simultaneously. By this method the hardening time can be greatly reduced over hardening a single gear with one burner. The arrangement of the setup is such that a flush quench is automatically applied when the flames are extinguished. This insures complete hardness of the rounded end of the gear tooth which is subject to clash condition.

By carefully adjusting the dwell time at the starting end and the exact position of the gas shutoff at the finishing end, it is possible to control accurately the depth of hardness on these clash ends.

Fig. 10 shows some large cast-steel crankshaft-lathe-tool bars which are hardened on four sides by the progressive flame-hardening method. It may be observed from the 6-ft rule lying on top of one of these bars that the three longest bars are 5 ft long, and the three shorter bars are approximately 4 ft long. These bars are 16 in. wide and 8 in. thick. Bars of this type ranging in size from 2×8 in. to 16×8 in. have been regularly flame-hardened on a production basis. These parts are first flame-hardened on the two wide sides and then hardened on the two narrow sides. The setup for this operation is shown in Fig. 11. It may be noted that the water level is very close ($^1/_8$ in.) to the surface of the work.

Deflectors are mounted on the two end burners to prevent water vapor from blanking out the flame, thus causing a back-flash. This practice makes it possible to apply the heat to the extreme edge of the work; thus the hardened area can be broken off sharply into a $^1/_8$-in. $\times$ 45-deg chamfer. When the two 8-in. surfaces of these bars are hardened, the water level is raised so that it is only $^1/_{16}$ in. below the surface. It is possible successfully to harden parts of this type without having soft streaks along the edge and at the same time avoid corner cracking which would occur if the aforementioned precautions were not taken. The average distortion of bars of this type is in the range of 0.003 to 0.010 in. Some of the advantages of flame-hardening a part of this type in preference to carburizing are as follows:

1 The number of operations is reduced 36 per cent.
2 The material cost is reduced $20 per ton.
3 Distortion is reduced 85 per cent.
   (*a*) This appreciably reduces the amount of grinding stock required, and
   (*b*) Insures a uniform hard case.
4 A slightly higher case hardness is obtained.
5 In large bars of the dimensions shown it was possible to change from a solid forging to a cored steel casting and thus reduce the weight of the part by approximately 35 per cent.

All of these advantages combine not only to make a higher-quality part but greatly to reduce the cost.

Fig. 12 shows a large crankshaft-lathe cam plate which was formerly made from a steel forging heat-treated to 269–302 Brinell and finish-machined. It was found that this hardness was not sufficiently high to resist the wear to which the part was subjected. However, it was almost impossible to harden it by the conventional method. An analysis of the service to which this part was subjected showed that the only requirements were a hard wear-resisting surface on the areas marked *A*, *B*, and *C* and that alloy cast iron would be entirely suitable from the standpoint of strength. In view of these factors it was decided to make the part from an alloy cast iron and harden the six surfaces by the progressive flame-hardening method.

The setup for flame-hardening this part is illustrated in Fig. 13. The three surfaces are hardened simultaneously, the part is turned over, and the similar three surfaces hardened on the opposite side of the bar. This method of production not only made it possible to furnish a more satisfactory part, but also re-

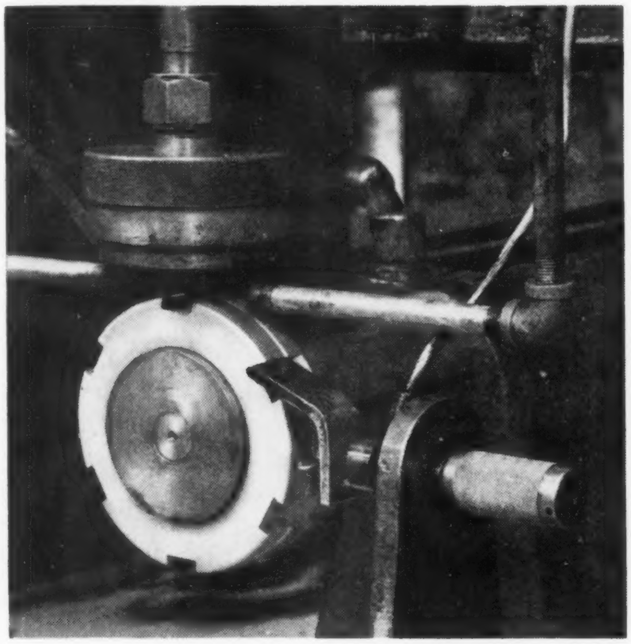


FIG. 4 SPOT-HARDENING OPERATION ON SPINDLE-NOSE COLLAR SPANNER-WRENCH SLOT

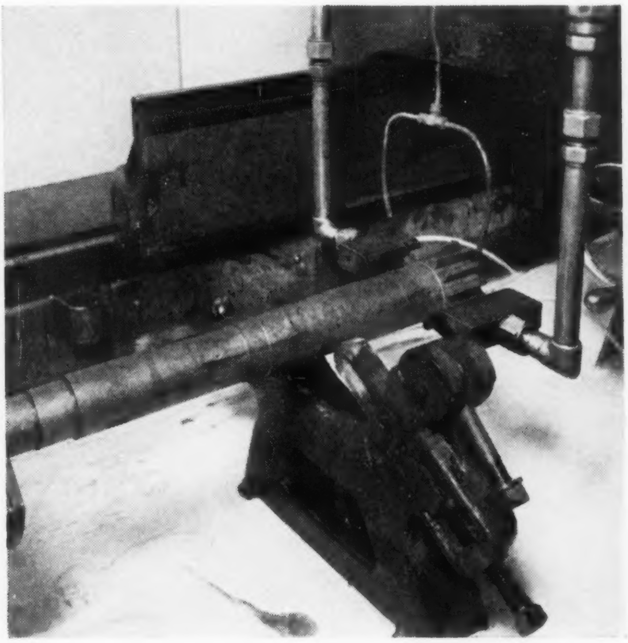


FIG. 7 PINION SHAFT—AN EXAMPLE OF A PART THAT CAN BE FLAME-HARDENED

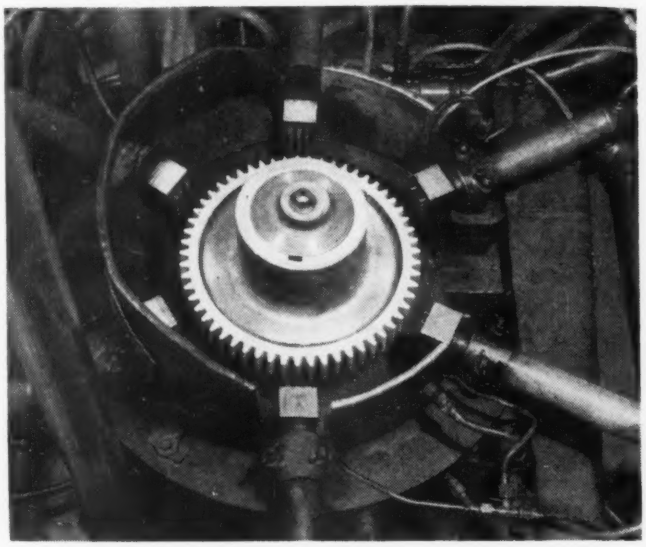


FIG. 5 TYPICAL SETUP FOR FLAME-HARDENING A 4-PITCH GEAR

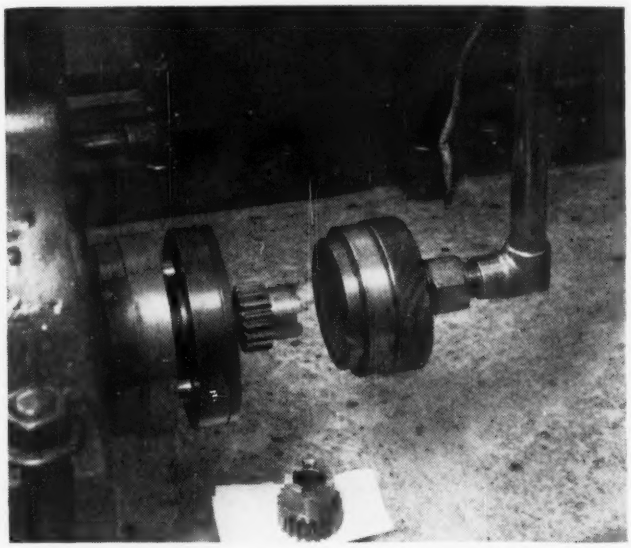


FIG. 8 POSITIVE TOOTH CLUTCH FLAME-HARDENED

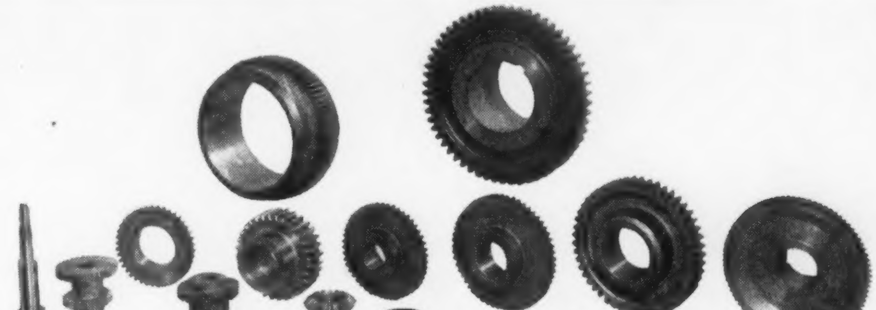


FIG. 6 GEARS REGULARLY SPIN-HARDENED ON A PRODUCTION BASIS

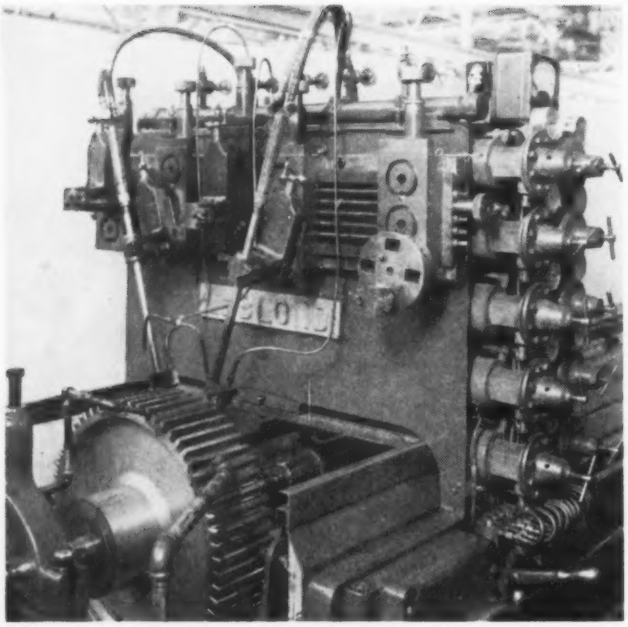


FIG. 9 GEARS FROM FOUR TO ONE DIAMETRAL PITCH AMONG THE MOST UNIVERSAL FLAME-HARDENED PARTS

(Two gears are set tightly together and two special gear-hardening burners applied simultaneously.)

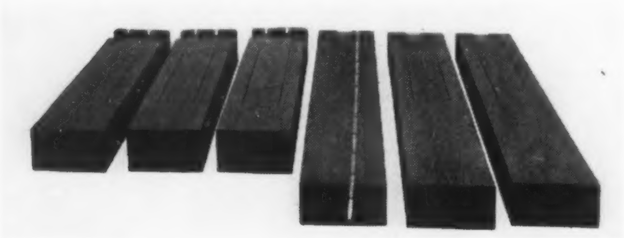


FIG. 10 LARGE CAST-STEEL CRANKSHAFT-LATHE-TOOL BARS FLAME-HARDENED ON FOUR SIDES

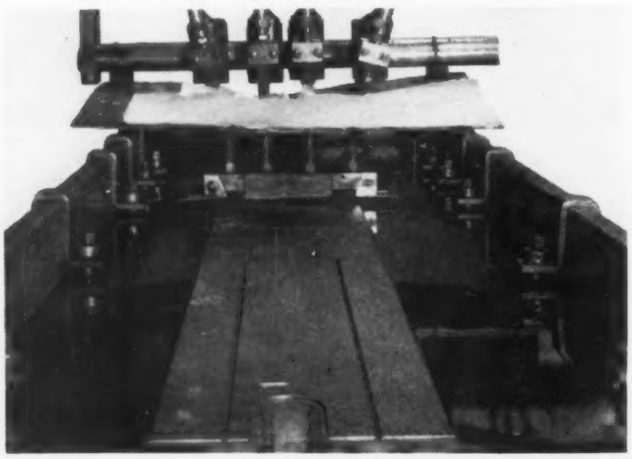


FIG. 11 SETUP FOR FLAME-HARDENING BARS SHOWN IN FIG. 10

(Note that water is very close to surface of work.)

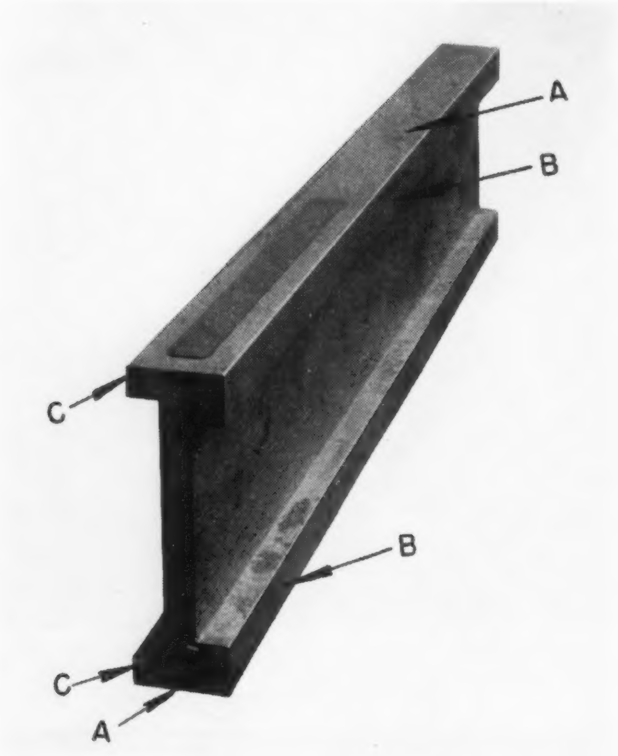


FIG. 12 LARGE CRANKSHAFT-LATHE CAM PLATE FLAME-HARDENED

(Only requirements were hard wear-resisting qualities on areas *A*, *B*, and *C*. These six surfaces were flame-hardened.)

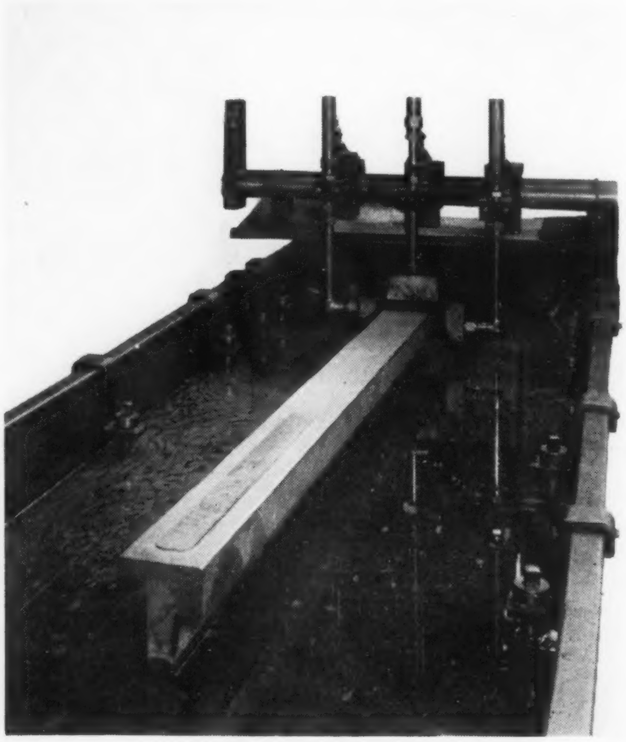


FIG. 13 SETUP FOR FLAME-HARDENING PART SHOWN IN FIG. 12

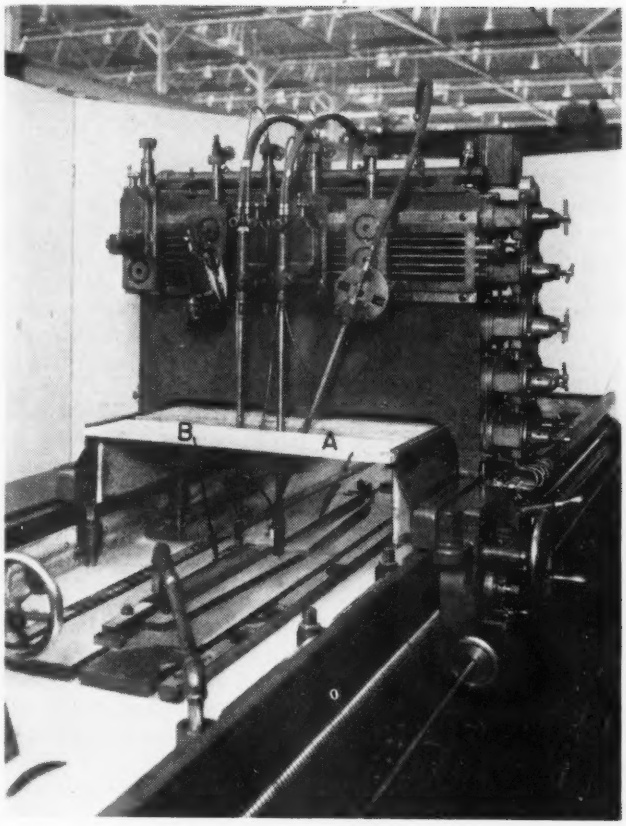


FIG. 14 TAPER-ATTACHMENT GUIDE BAR, A TYPICAL EXAMPLE OF FLAME-HARDENING LONG NARROW PIECE AT REASONABLE COST
(*A* and *B* only areas required to be hard.)

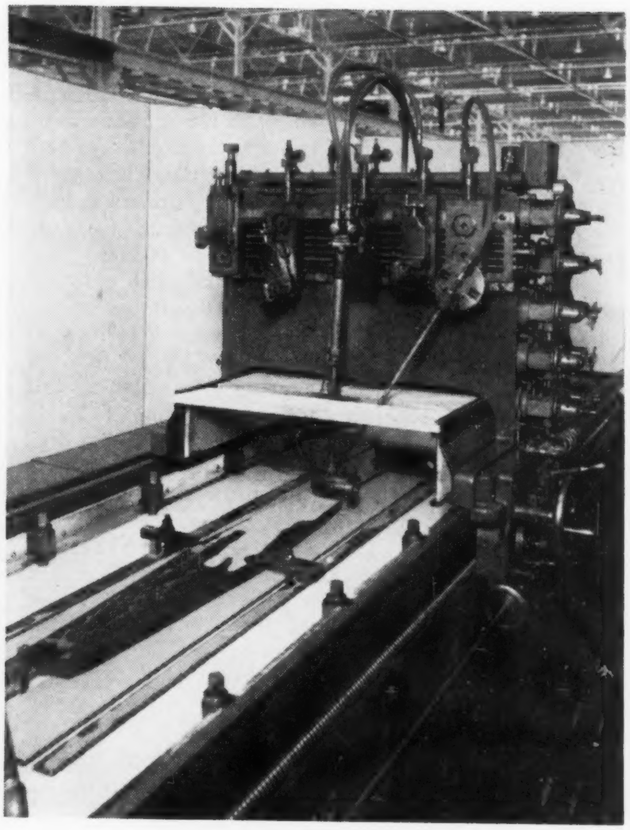


FIG. 15 SHOWS *A* AND *B* OF FIG. 14 BEING FLAME-HARDENED AND FLAME-STRAIGHTENED
(Maximum allowable distortion ± 0.010 in.)

FIG. 16 SETUP FOR FLAME-HARDENING $2^1/_2$ DIAMETRAL-PITCH PINION SHAFT

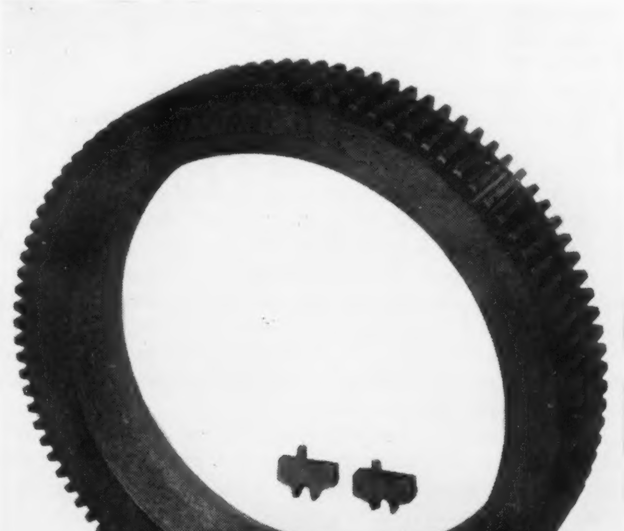


FIG. 17 LARGE RING GEAR, AN EXAMPLE OF A PART ALMOST IMPOSSIBLE TO HARDEN OTHER THAN BY FLAME HARDENING

sulted in a cost reduction of 40 per cent, or approximately $240 per part.

The taper-attachment guide bar shown in Fig. 14 is a typical example of flame-hardening a long narrow piece which probably could not be hardened by any other method at a reasonable cost. The only areas of this part that are required to be hard are the two sides *A* and *B*. These parts are flame-hardened, then turned over and flame-straightened, as illustrated in Fig. 15. The maximum allowable distortion is ±0.010 in. and the average actual distortion does not exceed ±0.003 in.

The setup for hardening a $2^1/_2$ diametral-pitch pinion shaft by the progressive-hardening method is illustrated in Fig. 16. This is a very simple setup and made it possible to solve satisfactorily a heat-treating problem that had previously been a source of trouble. The shaft is rather large and heat-treating the pinion end to obtain the localized hardening of the pinion caused an appreciable amount of distortion which was difficult to remove by the straightening operation. However, the flame-hardening process causes no distortion in the part and straightening is unnecessary.

The large ring gear shown in Fig. 17 is a typical example of one of the parts which would be almost impossible to harden by any method other than by progressive flame hardening. This gear has a bore of 16 in. and is 24 in. in outside diameter. It has been found that the progressive flame-hardening operation in no way increased the runout of the part and only resulted in a shrinking of about 0.001 to 0.002 in. in the bore.

More than 100 different jobs are now routed to the progressive flame-hardening machine and more than 9000 parts have been hardened to date by this method.

COMBINATION SPINNING AND PROGRESSIVE HARDENING

Fig. 18 shows a typical example of a combination spinning and progressive hardening setup. Although this particular photograph was made before the development of the present flame-hardening machine, the method of application is clearly shown. In this setup a $1^3/_4$-in-diam by 0.3000-in-lead Acme screw was hardened. A standard burner was set in the position shown and moved along the work surface while the work was being revolved at a speed of approximately 1000 surface inches per minute. A circular quench head immediately followed the burner and quenched the part. The steel used was S.A.E. X-1340. The resultant hardness of the thread was 52 to 56 Rockwell C. As would be expected, since it is known that when pearlite is transformed to martensite expansion occurs, the thread stretched a certain amount. However, by correcting the lead and cutting a thread with a pitch of 0.299684 in., it was found that a thread accuracy within 0.00005 in. per thread could be obtained, which is entirely satisfactory for most general-purpose applications. These measurements were made on a Zeiss optical instrument.

Fig. 19 shows another part which can be successfully hardened by the combination spinning and progressive method. This is a $^3/_4$-in-diam shaft 8 ft long with a $^1/_4$-in-diam pierced hole. The material is carbon tool steel. The surface hardness obtained ranged from 63 to 67 Rockwell C.

By proper arrangement of the burner equipment, the steady rest, and quench head, it is entirely practical to harden such parts on a production basis. With the possible exception of induction hardening, it seems impossible to think of any other method of heat-treatment that would permit hardening of this type of work.

SPECIAL BURNERS AND THEIR APPLICATION

It is frequently found advantageous to adopt special burners. The necessity for these special burners may be either to obtain better or more economical results. Fig. 20 illustrates one group of burners which are used in regular production work. The burner *A* is of such design that the flame length is very short. This makes it suitable for such parts as narrow keyways and other applications which could not be hardened with a standard commercial unit.

Burner *B* is used for hardening gear teeth by the progressive method. The application was clearly illustrated in Fig. 9. The design of this burner is governed by the pitch of the gear under consideration. This type must be so designed that the flame will be small and have a uniform length. A small fin between the gas and water holes is very helpful as it prevents the quenching medium from interfering with the flame action. This feature is especially desirable when the burner is used for hardening internal gears.

The burners *C* and *D* are designed for hardening two surfaces simultaneously. This type of unit can only be designed after extensive experimental work has been done with two separate burners to determine the exact location of the flame for the most satisfactory operating conditions. It may be noted that both are equipped with a heavy fin between the flame holes and the water holes. This fin is water-cooled to prevent its melting because of the high temperature. The advantage of such a fin is to prevent the quenching medium from interfering with the flames. It also provides a very sharp background so that the operator can more readily observe the surface being hardened. The set-up time for adjusting a burner of this type is much less than that required for setting two separate torches and burners.

The water-cooled circular burner *E* is designed for spot hardening or for use on a flat surface which can be spun or rotated as illustrated in Figs. 4 and 8. The flame plate *F* is merely a flat bronze disk, and any desired pattern of holes can be drilled to suit the part to be hardened. A burner of this kind can be used extensively for spot- or face-hardening parts of the same general design as those illustrated.

Burner *G* is a simple design and can be successfully applied with a small commercial welding torch. This burner is not water-cooled because it is not recommended for parts that would require a sufficient amount of heat to necessitate that precaution.

The valve burner shown in Fig. 21 is a universal one which has proved highly satisfactory for both progressive and spin hardening. Burner *A* in this illustration is used for progressive hardening. A practical application of this was shown in Fig. 15. A burner of this design is equipped with a tapered valve which can be revolved to line up the holes in such a manner that any desired number of flames from 2 to 32 can be applied on the work surface. The construction of this valve is such that it can be tightly clamped in position so that there is no gas leakage into the flame passages which are blocked off. This burner is equipped with quench holes which are immediately back of the flame holes and is suitable for all types of progressive flame-hardening work.

Burner *B* is of the same general design except the water circulating through the torch is only used to keep it cool. This makes it suitable for spin hardening.

Fig. 22 illustrates diagrammatically a setup for hardening a cast-iron crankshaft-lathe cam. Special contour burners are designed and spaced with the flames impinging on the work surface as illustrated by the dotted lines. The group of torches is moved longitudinally across the cam surface. This not only makes a hard wear-resisting surface but permits rapid heat-treating. It so happens that the design of these cams changes so slightly that the set of four burners illustrated has served to harden a wide variety of parts and very satisfactory results have been obtained.

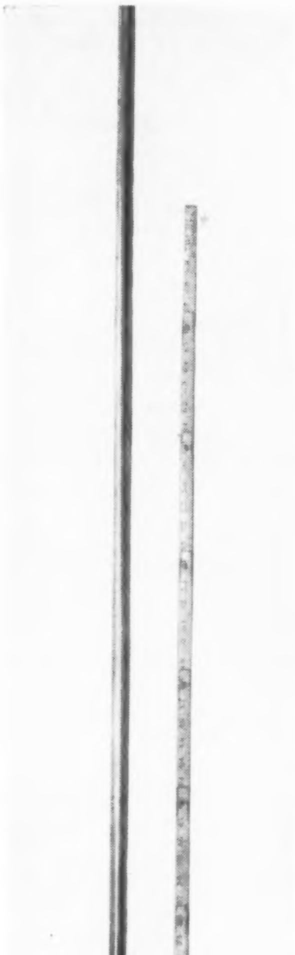


FIG. 19 $^3/_4$-IN-DIAM SHAFT OF CARBON TOOL STEEL 8 FT LONG, WITH $^1/_4$-IN-DIAM PIERCED HOLE, SUCCESSFULLY HARDENED

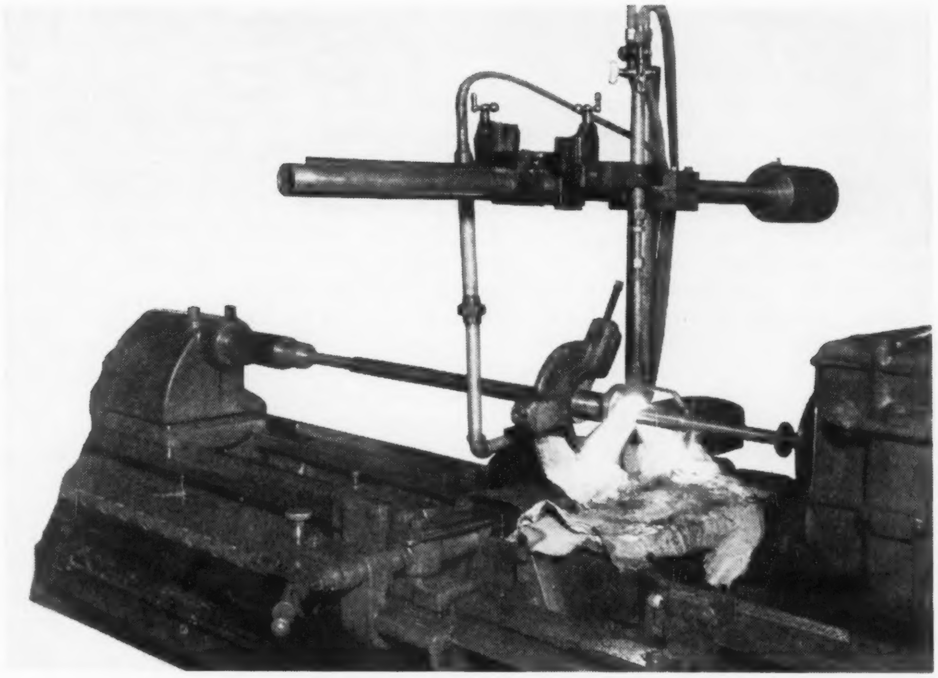


FIG. 18 TYPICAL EXAMPLE OF COMBINATION SPINNING AND PROGRESSIVE HARDENING SETUP

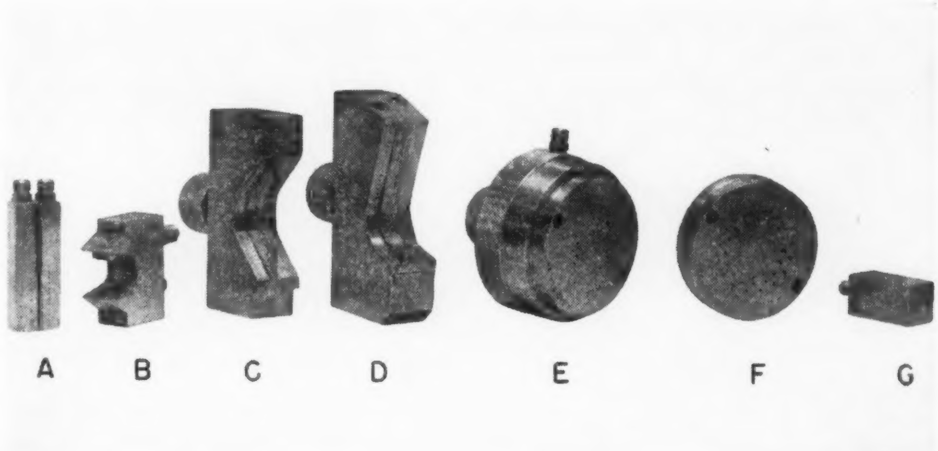


FIG. 20 GROUP OF BURNERS USED IN REGULAR PRODUCTION WORK

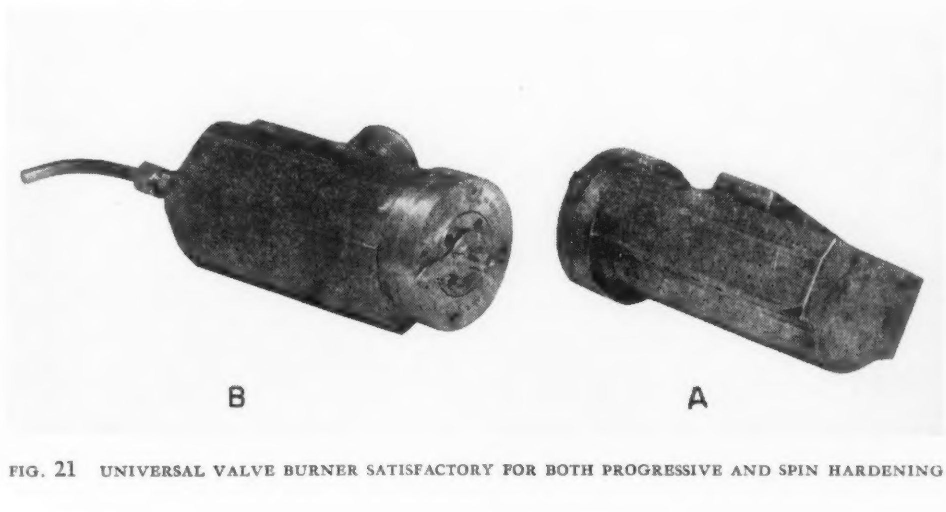


FIG. 21 UNIVERSAL VALVE BURNER SATISFACTORY FOR BOTH PROGRESSIVE AND SPIN HARDENING

STRAINS PRODUCED BY FLAME HARDENING

In considering the advisability of flame-hardening a given part it must be remembered that strains are set up by this operation. Flame hardening merely hardens a surface layer of the part treated. Actual tests have indicated that the stresses between the soft base metal and the flame-hardened surfaces are approximately 16,000 psi for chromium-molybdenum cast iron and 30,000 psi for S.A.E. 3140 or S.A.E. 4140 steel. These stresses can be reduced approximately 40 to 50 per cent by stress-relieving the part at 400 F for a moderate length of time.

The first reaction to the foregoing figures may be rather unfavorable. However, the stresses between the case and core of a flame-hardened part of S.A.E. 3140 steel are actually less than those which exist between the case and core of a piece of carburized and hardened S.A.E. 1020 steel. Tests have indicated that the stresses in the latter case are approximately 59,500 psi for an undrawn part and 34,800 psi for a part strain-relieved at 400 F.

This brief mention of the stresses set up by the two heat-treating methods has been made only because the designer must take them into consideration when selecting a part to be flame-hardened. A long part such as that illustrated in Fig. 14 would not be considered suitable for flame hardening if it had not been possible to flame-straighten it. However, if the part can be strain-balanced by flame straightening, there is no objection whatsoever to applying the flame-hardening method of heat-treatment.

An attempt is frequently made to avoid distortion by prebowing the part before the flame-hardening operation. Actual tests have shown that parts which were prebowed to such an extent that they could be removed from the flame-hardening operation practically straight would show $^1/_8$ in. distortion after a one-hour draw at 400 F. This definitely indicated that there would be a great tendency for parts which had been held straight by the prebowing process to distort as soon as they were put under strain of service. This would be especially true if they were subjected to any unusual shock conditions.

If a long slender part is of such design that flame straightening is not possible and prebowing is the only method of holding the part straight, it should not be considered a flame-hardening job.

CONCLUSION

In this discussion no attempt has been made to go into great detail on the technique followed on individual flame-hardening operations. The author has merely tried to point out some of the practical applications and in some instances to mention development work which was carried out. Although we have flame-hardened some 44,000 parts and have 235 different jobs routed to the flame-hardening department, in our opinion the process is in its infancy. Continued close co-operation between mechanical engineers and metallurgists in the application and development of the process will result in many vaulable improvements.

ACKNOWLEDGMENTS

The author wishes to express his appreciation to the *Iron Age* for their courtesy in allowing him to draw freely from the article, "Flame-Hardening Standardization," which appeared in that magazine as a series of articles from October 17 to November 14, 1940. He also wishes to acknowledge the splendid co-operation of The R. K. LeBlond Machine Tool Company and his co-workers in that organization.

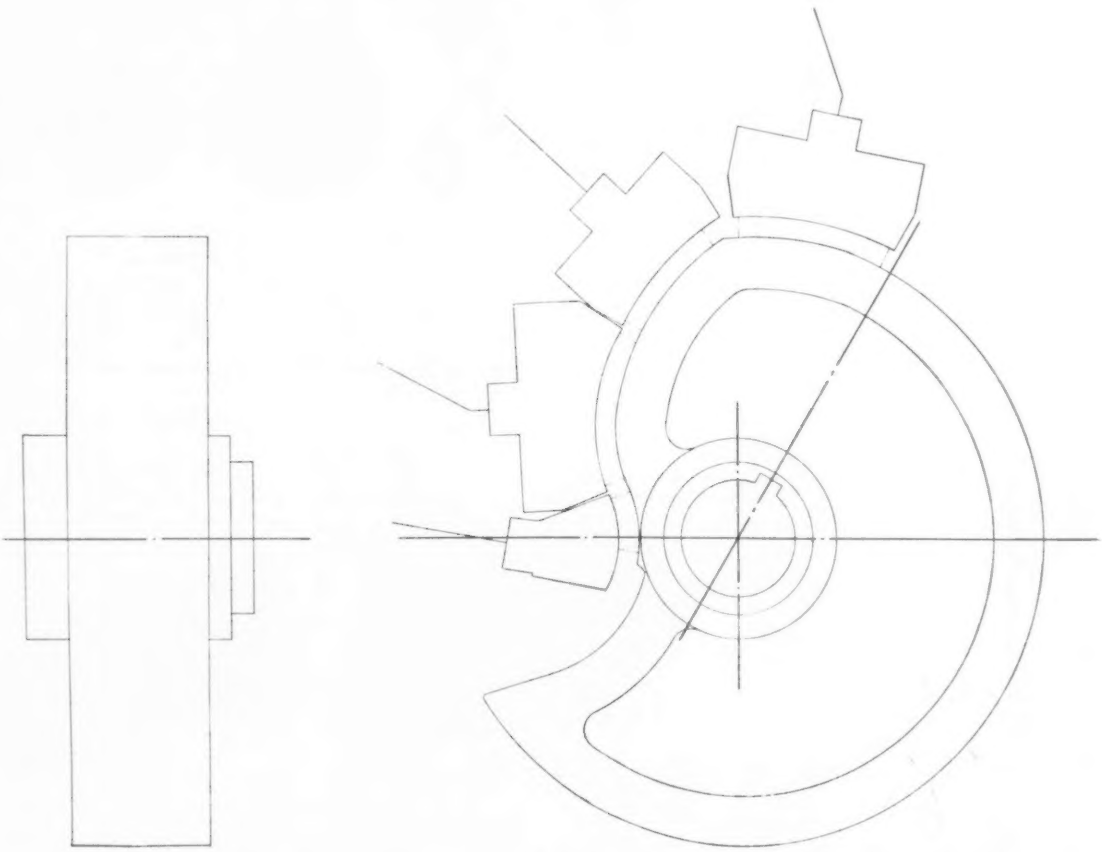


FIG. 22 ILLUSTRATES DIAGRAMMATICALLY SETUP FOR HARDENING CAST-IRON CRANKSHAFT-LATHE CAM

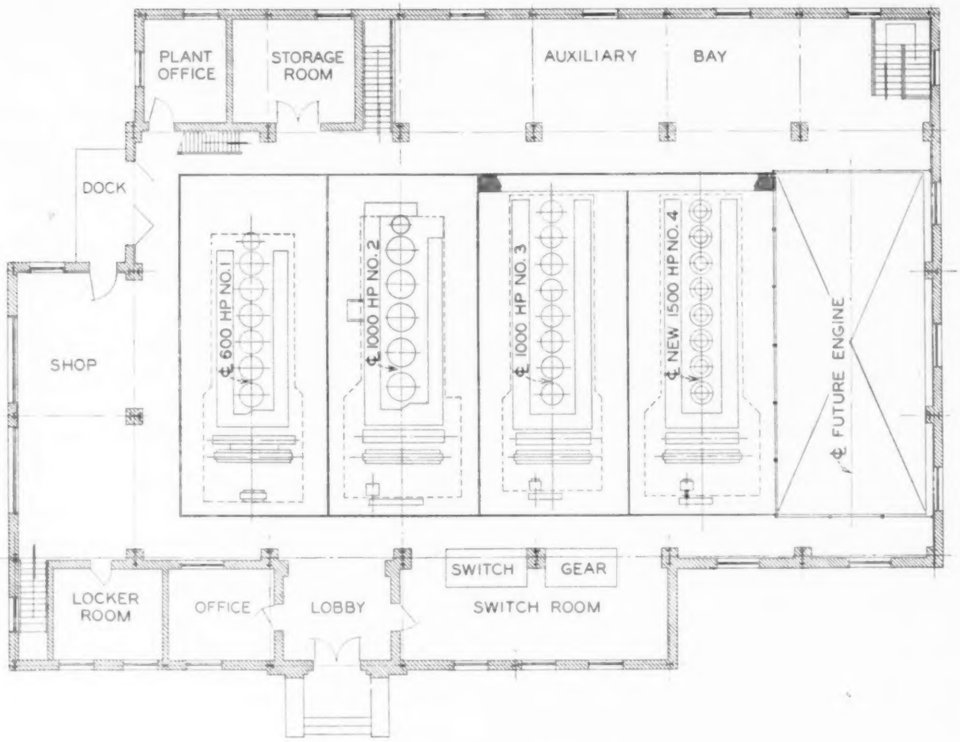


FIG. 1 OPERATING FLOOR PLAN

Design of INTERNAL-COMBUSTION ENGINE POWER PLANTS

By GLENN C. BOYER

BURNS & McDONNELL ENGINEERING CO., KANSAS CITY, MO.

IT IS obviously impossible to cover in a single paper all problems arising in the design of internal-combustion engine power plants, nor is it possible to go into exhaustive detail on many phases which will be discussed. This paper presents a general picture of plant design, and the author hopes to give engine and other equipment designers a better understanding of the problems involved in incorporating their creations into a successful plant and operators a better appreciation of the limitations faced by the plant designer.

Three distinct steps form the evolution of a plant:

1 Preliminary investigation—project economics, plant location, and unit sizes.
2 Selection and purchase of plant equipment.
3 Design of plant to house equipment purchased.

These three steps should be taken in order; if the plant must be designed before equipment purchase, a condition often forced on the designer, the final plant is rarely the best that could have been achieved.

This paper deals with the final step of the three, the coordination of equipment purchased and the creation of a plant to house it efficiently. It does not cover design of equipment, as such; that is the proper task of specialists.

Fundamentally, the evolution of a plant involves: (*a*) structural design—the proper proportioning of the plant building and equipment foundations and the strength of their component parts, (*b*) hydraulic design—selection of proper pumps for water and oil, selection of economic pipe sizes for the various liquids and gases to be handled, and proper location of pumps, valves, and accessories, (*c*) electrical design—selection of generators, switchgear, and cable, and arrangements of power supply for electrically operated accessories.

STRUCTURAL DESIGN

In the last 15 years changes and improvements in engine design have profoundly influenced practice in plant layout. A plant designed in 1927 to house units of 4000 hp maximum size would today house 7000-hp units similar to those at Vernon, Calif., or Tempe, Arizona.

The greatest change in our thinking has occurred in regard to equipment arrangement, foundation, and general structural design. The power plant built for central-station service must be designed so that additions can be made to it or alterations

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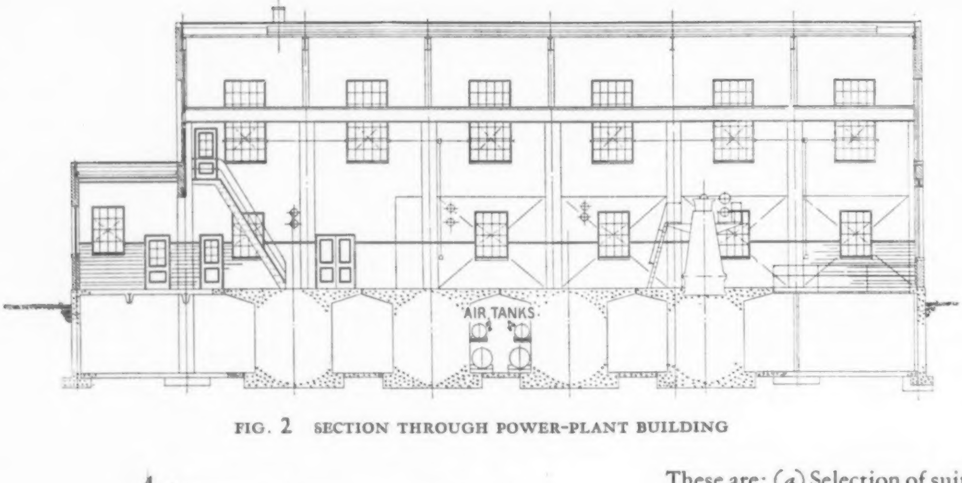

FIG. 2 SECTION THROUGH POWER-PLANT BUILDING

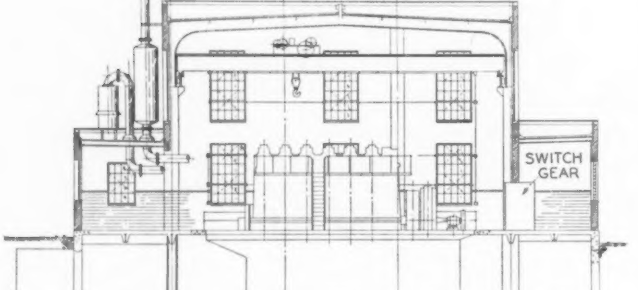

FIG. 3 SECTION THROUGH PLANT BUILDING

made within it, without the need for tearing down the entire existing structure. This requirement seems simple but its simplicity is apparent rather than real.

For example, need for flexibility dictates the kind of construction materials used. Thus, if the entire building and foundations are to be made of reinforced concrete, special care must be taken to insure that changes can be made without excessive expenditure of time and money. Our experience indicates that any building which must be extended or altered is best constructed with a reinforced-concrete substructure carrying a brick and structural-steel superstructure.

The fact that the typical power-plant building is in reality an overgrown box with no provision for interior stiffening by means of cellular construction as employed in office buildings makes it necessary to design for severe wind stresses. This means provision of sufficient stiffness by use of a suitable steel framework, in brick structures. Reinforced-concrete structures are extremely rigid; precautions must be taken to eliminate possibility of concrete destruction from engine vibration.

Previous mention has been made of foundation design (1)[1] and of the use of rigid-frame structures. The only further reference felt necessary is the arrangement of a recent power plant, shown in Figs. 1, 2, and 3.

Many arguments have been advanced for and against the basement in a power plant. Actually, the question is more or less academic. The fact that many engine builders require fuel- and lubricating-oil tanks and lubricating-oil coolers located below the crankshaft center line means that space must be provided for these accessories below the operating-floor level.

HYDRAULICS

The need for a basement to satisfy hydraulic requirements in some cases is only one detail in the whole range of hydraulic features involved in plant design. These include the fluid mechanics of turbulent and streamline flow of both compressible and noncompressible fluids having viscosities of widely varying values. Space prohibits going into detail regarding the hydraulic calculations necessary, especially as these matters have been fully treated elsewhere (2), but there are some features of the hydraulic conditions in engine-cooling systems which should be emphasized. These are: (*a*) Selection of suitable head-capacity characteristics for centrifugal pumps, and (*b*) proportioning pipe sizes to obtain an economical balance between fixed charges and additional power costs. Both matters require the exercise of good judgment as well as adequate engineering analysis of the entire cooling system. The problems are more or less interrelated.

Let us assume, for example, an initial installation of two 1000-hp engines, both to be operated occasionally and one continuously. Let us further assume need for two additional 1000-hp units during the next 10-year period and that the friction loss through the engine jacket and heat exchangers will total 25 ft. With a 15 F temperature rise, it is necessary to circulate 0.4 gpm per hp or 800 gpm when both engines are operating. When the next two engines are added, it is planned that there will be a maximum of three engines operating continuously.

Two designs of the jacket-water piping system using common headers for all engines give head-capacity curves as shown in curves A and B, Fig. 4. From the shape of these curves, and particularly curve B, it is apparent that if the smaller-sized pipe (curve B) is installed, pumps having steep head-capacity characteristics must be used. For a trial, assume that one 400-gpm and two 800-gpm units (27 ft total head, 39 ft shutoff head) are provided. One 800-gpm pump is for stand-by.

With only one engine running there is no advantage of A over B from the standpoint of head loss. When both engines operate, it becomes necessary to use an 800-gpm pump which delivers 780 gpm under the head imposed by system A and only 720 gpm against the head of system B. With 720 gpm delivered to the engines, the jacket-water temperature rise increases to 16.7 F.

Upon installation of the second pair of units, and with three units operating, the water required is 1200 gpm. With an 800-gpm and a 400-gpm pump operating, 1100 gpm will be de-

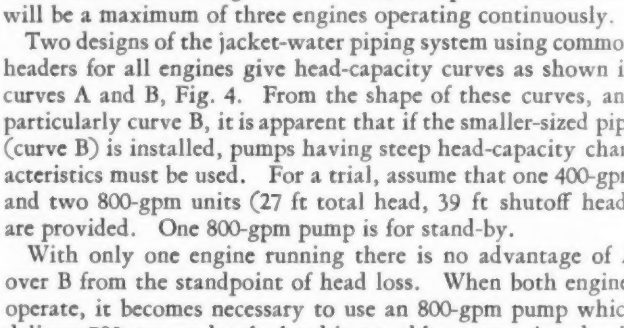

FIG. 4 HYDRAULIC STUDIES OF COOLING-WATER SYSTEM

[1] Numbers in parentheses refer to Bibliography at end of paper.

livered against the head of system A and only 910 gpm against system B. The temperature rise in system A becomes 16.3 F and in system B it becomes 19.7 F. Let us now compare the operating results for one, two, three, or four engines operating with systems A and B, Table 1.

TABLE 1 COMPARISON OF PUMPING CONDITIONS

Pumps operating	Engines operating	System A Gpm	System A Temp rise F	System B Gpm	System B Temp rise F
One 400-gpm	1	410	14.7	400	15
One 800-gpm	2	780	15.4	720	16.7
One 800-gpm, One 400-gpm	3	1100	16.3	910	19.7
Two 800-gpm	3	1325	13.6	1030	17.4
Two 800-gpm, One 400-gpm	4	1490	16.1	1080	22.2

The problem which the designer must settle for himself is whether the temperature rise of 19.7 F is satisfactory in the case of system B with three engines running or whether, in the event a fourth unit is required, a temperature rise of 22.2 F would be tolerated. It was our original design requirement to limit temperature rise to 15 F and system A approaches much closer to this requirement than does system B. It will generally be found that for most power plants it is wise to use too-large rather than too-small pipe diameters in the cooling-water system, and to provide a margin of safety for pipe fouling and increases in plant capacity beyond the original program.

Consider for a moment what would be the operating conditions if 400- and 800-gpm pumps had been selected for operation at 27 ft total head with a shut-off head of only 31 ft. Under these conditions the pumps would be practically useless for operation with more than two engines running.

AIR INTAKES

It is becoming increasingly apparent to those of us who have examined many internal-combustion engine power plants that too often sufficient care has not been exercised in eliminating noise and vibration which have their origin in the air-intake system. For a plant remote from human habitation, it is not necessary to give much thought to this nuisance condition, but where the plant is in a congested district, considerable care should be given to this matter.

Four-stroke-cycle engines are not such serious offenders in this regard, but two-stroke-cycle engines may be extremely troublesome in setting up air-borne vibrations which can cause annoyance at a considerable distance from the plant.

There are several things which may be done to reduce this noise nuisance or in some cases eliminate it entirely. The methods include:

1 Use of intake-air muffler.

2 Provision of suitable plenum chamber between air filters and engine.

3 Use of venturi nozzle in entrance of air-intake pipe.

Care must also be exercised to insure that the air intake is located so that it will not cause vibration of adjacent structures. This requires that air intakes should not be located too close to the roof of the plant or in a confined space.

ENGINE EXHAUSTS

Suitable muffling equipment is available today for all types and capacities of engines and is almost universally used. Construction from the engine to muffler has not been standardized, and probably cannot be, because of many different exhaust-manifold designs. In planning exhaust conduit or piping from the engine to a muffler, suitable provision must be made for expansion. Occasionally, a concrete exhaust duct is constructed under the engine-room floor for conveying the exhaust gases from the engine to the muffler. Here, also, provision must be made for expansion. If not, serious damage may be caused to the engine and generator foundation block as was the case in one installation examined recently.

ELECTRICAL EQUIPMENT

There are some features of the electrical equipment of an internal-combustion engine plant which it is desirable to present in order to clear up some of the mystery that surrounds this part of the plant. I refer to the rating of electrical generators and the selection of proper oil circuit breakers for use in the plant.

The standard rating for slow-speed engine-driven alternators is based upon a 50 C temperature rise at full load in the stator windings when class A insulation is used and the alternators operate at 80 per cent power factor. Any variation from these basic standards results in a special machine which generally requires an increase in the purchase price. This standard temperature rise of 50 C is based upon an ambient air temperature of 40 C (104 F) which was chosen after studying prevailing summer temperature conditions throughout the United States. Consider for a moment that the "hottest spot" temperature permissible for class A insulation material is 105 C. With an air temperature of 40 C, a correction of 15 C required to be added to thermometer readings of winding temperatures, and a temperature rise of 50 C measured by a thermometer, a "hottest spot" temperature of $40 + 50 + 15 = 105$ C is obtained, which is the allowable "hottest spot" temperature for this class of insulating material. In some sections of the United States, however, summer temperatures in generating plants exceed 40 C (104 F) for considerable periods of time. When such conditions occur, it is not possible to employ class A insulating material and still have a "hottest spot" temperature of 105 C when a 50 C rise is experienced. Since class A insulating materials are generally used for engine-driven, slow-speed alternators, it becomes necessary to operate at full load with a temperature rise less than 50 C under such conditions. In such an instance, a 40 C rise machine is used with which it is possible to obtain full load with the ambient temperature in the engine room of 50 C (122 F).

Such a machine is more expensive than a 50 C rise unit, but it has the advantage of being able to deliver 125 per cent of rated capacity for two hours with a temperature rise of 55 C when the ambient air temperature is 40 C.

Occasionally, the operator of an internal-combustion engine plant insists upon purchasing an alternator designed for power factors ranging from 60 to 70 per cent, hoping thereby to eliminate some of the operating difficulties experienced with derating alternators designed for 80 per cent power factor when the system power factor is less than 80 per cent. The answer in this case is to improve the power factor of the load being supplied rather than to attempt to operate generators at power factors lower than 80 per cent.

Altitude above sea level influences the capacity of an alternator. Basic designs for 50 C rise machines are satisfactory for full-load operation at elevations up to 3300 ft above sea level. Elevations above 3300 ft require modifications in generator design at an increased cost for the unit. Generators rated for 40 C rise are satisfactory for full-load operation up to and including 9900 ft above sea level although they carry no overload guarantees when operating at altitudes above 3300 ft.

Circuit breakers of either the oil or oilless type are used to protect electrical generating equipment from the serious effects of sustained short circuits. In order that the breaker may perform its functions satisfactorily, it is necessary that it possess suitable electrical and mechanical characteristics. The breaker must successfully interrupt the maximum kva that it will be

called upon to handle and, in addition, it must possess sufficient mechanical strength to withstand the forces created by the initial current inrush during a short circuit. At the present time breakers for 2400 and higher voltage service are rated in kva interrupting capacity and one- and five-second current-carrying capacities.

Decrement curves (3), Fig. 5, have been developed to give the current flow for machines of various reactances and for various periods of time following the start of the short circuit. The application of such curves is shown in the following example:

Consider a three-phase, 2400-volt, 60-cycle generator, of 500 kw (625 kva) capacity, supplying two feeder circuits. Assume a short circuit occurs adjacent to the terminals of one of the feeder breakers.

Known conditions:
Generator capacity, 500 kw or 625 kva
Generator voltage, 2400
Generator reactance, 22 per cent subtransient

$$\text{Full-load current, } \frac{(625)\,(1000)}{(1.732)\,(2400)} = 150 \text{ amp}$$

From Fig. 5 the initial current inrush at 0.008 seconds or the first one-half cycle for 22 per cent reactance is 8.0 times the full-load current. The initial inrush then becomes

$$(8.0)\,(150) = 1200 \text{ amp}$$

If the breaker is set to open in 15 cycles or 0.25 sec, again referring to Fig. 5 it is seen that with 22 per cent reactance the kva to be interrupted is 3.55 times the rated generator kva. Therefore the load which the breaker must interrupt is

$$(3.55)\,(625) = 2220 \text{ kva}$$

A 2500-volt breaker having a normal current-carrying capacity of 200 amperes, a one-second current-carrying capacity of 10,000 amperes, and an interrupting capacity of 10,000 kva will be satisfactory. This is the smallest standard breaker that can be secured for such a condition.

For calculations where several generating units are connected to the bus at the same time, the equivalent reactance of all machines operating must be computed. A typical calculation runs as follows:

Generator	Capacity	Subtransient reactance
1	3125 kva	20 per cent
2	1875 kva	22 per cent
3	1000 kva	24 per cent

$$\text{Reactance, generator No. 1} = \frac{(6000)\,(20)}{3125} = 38.4 \text{ per cent}$$

$$\text{No. 2} = \frac{(6000)\,(22)}{1875} = 70.5 \text{ per cent}$$

$$\text{No. 3} = \frac{(6000)\,(24)}{1000} = 144 \text{ per cent}$$

Since the total reactance at the bus is the reciprocal of the sum of the reciprocals of the individual values calculated, the value is obtained as follows:

$$\text{Reactance} = \frac{1}{\dfrac{1}{38.4} + \dfrac{1}{70.5} + \dfrac{1}{144}} = 21.2 \text{ per cent}$$

CONTROL OF AUXILIARY EQUIPMENT

The electrical control for auxiliaries in the power plant should be simple, rugged, and dependable. Because the circulating water pumps are the most essential plant auxiliaries, it is necessary to insure that they will operate whenever the engine is running.

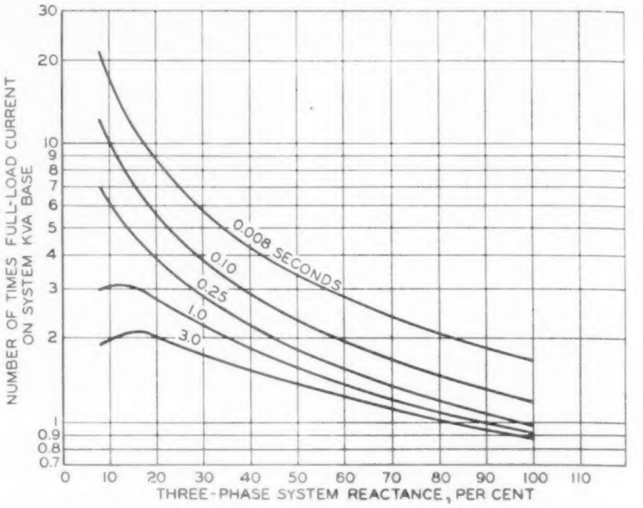

FIG. 5 SYSTEM SHORT-CIRCUIT CURRENT (OR KVA) FACTORS FOR THREE-PHASE SHORT CIRCUIT ON THREE-PHASE SYSTEM

In view of this requirement, control equipment for starting and stopping cooling-water pump motors must be as nearly foolproof as possible. Electrical contactors employed in conventional motor starters are a source of trouble, and our policy is not to use the conventional push-button starting equipment for cooling-water pump motors. In fact, it has been our experience that the best control for such auxiliaries is a low-voltage manual air circuit breaker from which the thermal-trip elements have been removed. With only the magnetic-trip elements left in the breakers, continuity of operation of the motor is assured under all conditions except a dead short in the motor or the power-supply leads to the motor.

This may seem a somewhat drastic policy, but our experience indicates that a control assembly of this character is necessary for essential plant auxiliaries.

WIRE AND CABLE

The selection of wire and cable for power circuits and station power supply involves consideration of circuit voltage, current-carrying capacity, and types of insulating materials available. Unfortunately, the subject is too involved for adequate presentation as a portion of this paper. Like pipe sizes for cooling water, wire sizes should be too large rather than too small.

Changes made in the code requirements for current-carrying capacities of copper conductors have necessitated the use of larger conductor sizes for a given current value than was formerly considered necessary.

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Benefits of MATERIAL STANDARDIZATION

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MATERIAL standardization is a valuable ally of management, whose purpose is to advance constantly toward a higher plane of efficiency with increased savings and improved quality of product. The importance of material standardization is indicated by the fact that the outlay for materials is the largest single item of cost for the average manufacturer. The 1929 Census Report showed that, for all manufacturing industries, the combined cost of materials, fuels, etc., was 54.7 per cent of the value of output.

In times of emergency, material standardization is especially necessary in order to systematize the supply function, to render production materials readily available, and rapidly to train new employees in the company's material requirements. Time is vitally important in the conduct of modern warfare, and this factor applies to industry fully as much as it does to the strategy in the field. It was the first World War, bringing with it the necessity of obtaining from American industries the maximum of production with the minimum of expenditure, which pointed the way, through standardization, to the elimination of industrial waste and to the conservation of our raw materials, finished products, and labor. Standardization of industrial production has been one of the important factors in enabling Germany to maintain its industrial machine intact in the face of the multitude of obstacles now confronting that nation.

For convenience, the advantages which accrue to an enterprise by the adoption of material standards have been more or less loosely classed under the departments affected.

Definitions. Definitions of the various phases of material standardization should first be established to prevent confusion as to the exact implication of the subject. Material standardization for a particular firm is conducted by a material standards department in collaboration with standards committees and the purchasing, engineering, inspection, and stores departments, together with the co-operation of the producers. This organization, through inventory analysis and research, establishes and maintains the following:

Material Standards. A material standard is defined as that material which, at any given time, is the best and most economical quality, form, and size for the service required, or is a reasonably attainable maximum of desirability. It is established by general consent as a result of engineering study combined with experienced operation.

Simplification. Simplification concerns the act of reducing the types, grades, forms, or sizes of materials employed to the fewest number consistent with successful operation. It also comprises the establishment of correlated interrelations, such as preferred dimensions, seriation of grades, dimensions, and tolerances, as well as chemical, physical, and other serviceability factors.

Purchase Specifications. The material or purchase specification is the medium used for expressing the material standard so that it may be clearly understood by the vendor, the buyer, the inspector, and the user. Purchase specifications are complete systematically written descriptions of the material to be purchased, sufficiently accurate and definite to insure receipt at the least cost of the quality required for satisfactory use. The specification is composed of the name of the material, the symbol of the material, and a statement of the uses for which it is intended. It also contains carefully prepared statements in measurable terms of chemical analysis, physical properties, and dimensions, including methods of testing and sampling, together with other qualities such as form, finish, and manufacture.

Standards-Catalogue Data. The standards-catalogue data are for use within the company and cover (*a*) engineering data and (*b*) ordering, cost, and stock data. The engineering data present the recommended standard materials sponsored by the company technical committees, identify company specification symbols, and establish a standard nomenclature. For assistance in selecting and utilizing materials, comparative data are given as to the specification requirements, as well as other properties. The ordering, cost, and stock data indicate preferred ordering methods, and list recommended standard orders and ordering points. Pertinent cost information is given, including an outline of cost build-up. Standard and preferred standard material stock sizes, special stock, and nonstandard stock are also recorded.

MANAGEMENT

Economic. Material standardization affects every phase of design, procurement, and production; the more important gains realized are a reduction of direct and indirect costs, a systematizing of business, and an improvement in the manufactured products. In the industries to which it has been applied, the scientific standardization of manufacturing materials has succeeded in bringing about major economies in material, labor, and administration, and a lower cost and better control of operations.

To illustrate its economic importance to management, it is estimated that a minimum of 10 per cent direct saving on the purchases of any item investigated is possible. Standardization, by causing a careful investigation to be made into all phases of the material and its suitability for the service required, precludes the possibility of a quality better than needed, as well as financial losses resulting from the use of cheap but low-grade materials. Specifications are drawn so as to eliminate every item of expense that does not add to the real service of the product. Simplification eliminates numerous and sometimes unsuitable variations of grades and sizes of materials. It aids the consolidation of purchases, thus decreasing quantity and cutting extras, and buying from warehouses, which necessarily must add an additional handling charge.

The cost of the material-standardization program is more than offset by the indirect savings effected, comprising better quality and greater uniformity of the materials, an increase in their ease of manufacture and in their improved service, made possible through greater knowledge. Furthermore, the use of nationally recognized standard materials reduces cost, because

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these materials can be manufactured in the largest quantities, resulting in decreased unit cost and increased uniformity in output, which in turn contributes to economies in production.

However, for the most part, few data are available to show specific economic results of the indirect savings of material standardization. The reason for this is that the process involves changes in existing procedures and, since these modifications are usually made gradually, it is extremely difficult if not impossible to segregate the effect or to evaluate it.

Systematization. Material standardization is necessary for routine operation of the business, for creative planning and organizing; hence the development of a system, and the application of the exception principle of management. Primarily, through the medium of effective material specifications and standards catalogue data, basic tools of thought and expression, words or terms, abbreviations, symbols, definitions, and the interpretations and conditions governing their use are standardized.

The setting forth of standards in writing, furthermore, has the obvious advantage of fostering clarity and understanding, a matter of especial importance in large organizations. After a specification has been written, all parties interested in the subject, even those who are not experts, will know what to look for, and to a certain extent how to measure the value of the material under consideration. Thus, a sound basis is laid for rational judgment of things by those who, before standardization, had been more or less subject to indefinite and unverified claims made for the material.

The development of a satisfactory logical system of symbols furnishes one of the most important aids to the handling and recording of materials. The major reason for classification and symbolization is the establishment of an orderly, organized, arrangement of facts and information, and the consequent ease of reference thereto. These standardized representations, groupings, and arrangements save mental effort, time, and expense, and prevent troublesome and costly errors. They aid in recording, transmitting, and comprehending ideas and instructions, and reduce the expense and inconvenience of mistakes and misunderstandings.

The standards catalogue by establishing correct terminology assures uniformity in specifying materials on requisitions. The description of the material is shortened, and requisitioning is simple and economical. Standardization of nomenclature reduces all other clerical overhead and produces a simplified, more accurate cost-accounting system. Material standardization and simplification save a multitude of diverse inquiries, invoices, payments, receipts, stock and property accounts, due to the decreased variety and number of working materials used. The work of ordering, accounting, and auditing is thereby reduced.

Technological. An important engineering function of standardization is to analyze the job as a whole and then to analyze the service characteristics of all materials in any manner suitable for the use intended. It fixes the attention of all interested parties upon conditions to be met and upon material performance, properties, and dimensions, both in production and in use, to the end that the greatest industrial efficiency may be attained. Differences in practice between departments and plants facing the same problem are reconciled and new ideas in the selection and use of materials are exchanged between committeemen and between plants.

Thus is readily facilitated the elimination of definitely inferior materials and practices, or items too good for the job, which are merely the result of accident or tradition. If several types of materials are available, by means of records, research, engineering counsel, and co-operation of using departments, assurance is provided that the grade and quality of materials purchased shall be precisely adapted to requirements. Furthermore, written purchase specifications separate the significant from the inconsequential, and measurable qualities from those which are intangible and perhaps unreal. Thus, technological benefits are produced which in turn are reflected in a higher quality, as well as in a lower cost of the manufactured product.

Development. The relation between material standardization and research may be summarized by saying that the two are complementary factors. Standardization can be accomplished only after the facts have been investigated and an agreement has been reached on controversial points. This in itself makes evident the need for preliminary research and development. Furthermore, standardization is one of the principal means of getting the results of research and development into actual use in industry. This has produced a co-ordination of resources and effort insuring more orderly expeditious progress.

Standardization also favors development work and the quick utilization of new research, by affording a definite point of departure at which new studies and improvements in design and manufacture as well as materials can begin. The standards catalogue by listing all the present standard materials leads to discussions of their use in terms of the adequacy with which they cover the company's normal requirements. It brings out the need of new facts, so that what is best and most economical may be determined, and agreement on moot questions secured.

PRODUCTION

Correct and Uniform Material. Material standardization is invaluable to the large consumer who commonly draws his materials from several sources of supply. Its proper application in such cases serves to present complete technical information and thus to promote a common understanding between producer and user and insure that materials from different sources will be of suitable and uniform quality. If the manufacturers are consulted during the preparation of specifications, they will be able to advise whether the material to meet the requirements can be produced, and if not, what can be furnished. Valuable suggestions as to minor changes may also be given that will allow commercial products to be furnished instead of special grades, thus insuring utmost economy in production and the least delay in shipment.

Uniform quality of manufacturing materials is essential to orderly and high-speed industrial production. A strict control of the material quality by suitable purchase specifications and inspection control promotes precision and eliminates the receipt of defective material which must be rejected or scrapped. Thus, assurance is obtained against loss due to labor and machine time being expended and extra handling and delay entailed in obtaining new material. In addition the situation is avoided wherein it might be necessary to use the inferior materials, incurring the expenditure of an undue amount of time and labor in partial remanufacture or patching to eradicate defects and even, perhaps, with the sacrifice of quality in the finished product.

Delivery. It is evident that with standard materials there will be greater ease in securing raw materials. By the use of a comparatively small number of materials which can be carried in stock, a supply is always available for fabrication. This relieves the production department of the burden of ordering special material, of contending with delayed shipments and even, perhaps, with defective material. In times of emergency, especially, standardization renders material supplies readily available.

Inventory simplification also permits larger orders which in turn are productive of better delivery service from the suppliers.

In addition, more effective stocks are maintained by distributors and manufacturers of standard materials.

PURCHASING

Material standardization will assist considerably in carrying out the fundamental elements of efficient purchasing which are stated as:

1 Uniform suitability of the material to the requirements.

2 Availability of the material which covers deliveries, service, and the time element, including turnover problems.

3 Credibility or responsibility of the suppliers.

4 Price.

To the purchasing department which is anxious to effect real economies in buying, standardization and simplification offer greater possibilities than the field of price bargaining. From the standpoint of reducing manufacturing expense, it is more important that the purchasing agent aid in developing standardization within his plant than it is for him to attempt to cut the unit price of any article on his list of purchases. Care should be taken to make all purchases on detailed specifications. The importance of using materials best suited to the work and which are uniform in quality, and by simplification reduced to the smallest variety, is not sufficiently appreciated by the buyer in even the systematized plant.

Simplifies Routine. Material standardization, primarily through the reduced number of items to be purchased, and in turn the reduced number of orders to be issued, logically decreases the direct expense of purchasing. This is true because where the material requirements are fully standardized, a small purchasing force can turn out more work than a staff twice its size working under the handicaps of nonstandardization.

Furthermore, standardization of nomenclature simplifies the details of purchasing, eliminating lost motion, and preventing unnecessary phone calls or correspondence to requisitioners. It simplifies the problem of requisitioning, since standard materials need not be described in detail, but may be referred to by a recognized name, and a generally accepted capacity or size designation, or number. Except where specifically noted otherwise, the article description given in the standards catalogue includes the necessary information for proper purchase. Thus mistakes in specifying materials are prevented and each material is made more recognizable, eliminating purchasing-department uncertainty. In turn, the buyer is enabled to use the correct description on the purchase order, reducing confusion and misunderstanding on the part of the supplier, and assuring receipt of the exact material required with less time lost in shipment.

The buyer spends none of his time rewriting the requisition to make it intelligent to the vendor. Standardization also relieves the purchasing department of the task of locating sources of supply for special materials. Therefore the purchasing department is free to put all its efforts on selecting the vendor who offers the best competitive price, terms, and delivery.

Aids Competitive Buying. Whenever possible, purchasing executives follow the policy of purchasing from two or more sellers of a given material. It is unwise to depend upon only one source, since a situation might arise which would render that source unsuitable. Also, it is a basic principle of purchasing that competition reacts to the benefit of the purchaser, for he is put at an advantage in bargaining, arranging adjustments, and obtaining lower prices.

By the use of standard specifications only, it is possible to bring about a condition of truly competitive bidding and insure comparative quotations. As a matter of fact, this is one of the fundamental objects of preparing specifications, i.e., to determine the equation between cost and performance, and then to set competing bidders into the position of furnishing goods of equivalent service value at prices reflecting their respective degrees of initiative, skill, and efficiency. By the use of specifications combined with the wider use of correct terminology and specific engineering requirements, and the removal of trade-name restrictions, the sources of supply and the availability of materials are increased. Furthermore the continual quarrel between quality and price, one of the most difficult problems of purchasing, is cleared only by proper and adequate specifications. Purchasing by bids based on well-formulated specifications really sets an upper and lower limit of the quality. The "too good" is eliminated in the price comparison of bids; the "too poor" is rejected by the minimum quality specified.

A full and precise specification also greatly enhances the trading reputation of the purchaser for exact knowledge of his needs, encouraging competition among the most desirable vendors. It informs the dealer that a scientific basis for fair dealing has been furnished, and also that he is not bidding against some other manufacturer supplying inferior material.

Approved Suppliers. Raw-material manufacturing plants differ in the degree of control they give to their plant operations, in the adequacy of their equipment to perform the operations required, and in their willingness to take a chance that their product will get by when it is on the border line between good and poor material. Because of this, it is advisable to combine buying on specifications with an approved list of manufacturers who have proved their ability to furnish uniformly good material to the specification and to produce the quantity required with efficient service and the right price. Furthermore it is common practice for purchasing agents to limit the issuance of inquiries and orders to such an approved list which is determined also by the vendors' financial responsibility, fair selling policies, and their standing in the trade to which they belong. Manufacturers' names may of course be taken from or added to the list from time to time, depending on experience.

The advantages of the practice of limiting inquiries and purchases to lists of approved suppliers include gaining that security which comes from knowledge of the integrity and capability of a source of supply; the assurance that, specifications having already been submitted to these approved suppliers, they fully understand the requirements and the maintenance, to a degree at least, of a competitive condition, since invariably such lists include more than one potential source of supply for each item to be bought.

Using specifications as a means of supplementing friendly relations between buyer and seller, as indicated by an approved list, gives the buyer a double guarantee; makes it possible more easily to trace whatever complaints may arise and to fix the blame. Also in this way it is often possible to eliminate the necessity for a complete check on the material received in every shipment and thus save considerable inspection expense. This accredited list is also quite necessary when the tests, which would otherwise be required to determine the suitability of the specified material purchased from unproved vendors, are such as to require the use of testing equipment of a complicated or expensive nature.

ENGINEERING

Quality standardization of engineering materials and practical engineering are so closely associated that the practice of engineering without material standards and purchase specifications is a practical impossibility.

Complete and accurate information is made available in the standards catalogue regarding the composition, general properties, and uses of the standard materials. A ready comparison of grades available, data on treatments, machinability, and weld-

ing characteristics is provided. This information is of great value to the designer, planner, buyer, and shops, enabling all to apply the materials more effectively.

With this as a guide, anyone requiring, for example, a steel for a certain purpose, by consulting the indexed catalogue, can readily determine the most suitable material. The designer or engineer is encouraged to consider what is offered and if necessary to vary his design factors slightly to permit the purchase and utilization of one of the standard materials listed. The requisitioner, with the aid of ordering data also provided in the standards catalogue, copies on the requisition the name of the material, the company specification number, the form, size, and quantity required.

Standardization of this kind eliminates considerable questioning and discussion and reduces the work on the part of the draftsman in deciding what material and size to use, as he has only a certain specified material and size that he is permitted to use. The adoption of these standards has relieved designers and engineers of a great amount of drudgery on all minor details and left their minds clear for important nonroutine work.

In addition, the establishment of standardization simplifies and reduces the cost of instructing new employees, because there are fewer things with which to become acquainted, and because it is no longer necessary to learn by trial and error what is in stock and what is standard.

Inspection. Inspection is the art of applying tests by aid of measuring appliances to observe whether a given material is within the specified limits of variability. Purchasing specifications equip the inspector of incoming purchased material with definite tests and measures, avoiding either too lax or too stringent inspection, by which to determine whether the correct quality and quantity of material is being received and on which to reject inferior goods. Unless definite standards and specifications are established outlining these limits, it is obvious that there can be no intelligent inspection. Standardization simplifies inspection of materials and cuts down the cost of this work to a minimum since the inspection follows a definite routine.

Also essential in checking the quality of materials are well-trained inspectors, adequate testing laboratories, and sound methods of testing, upon all of which factors the test values determined for the materials often largely depend. Standard methods of sampling and testing outlined in the purchase specifications enable both producer and consumer to test the material in the same manner and obtain comparative results. By providing a workable basis of acceptance and rejection, there is consequent reduction in controversies with suppliers over rejected material.

By reducing the number of items to be purchased and inspected, simplification and standardization also reduce the work of the inspection department.

STORES

Simplification of the quality, form, and size of materials employed reduces the number of materials to be kept in stock, and tends for quicker turnover, both of which aid in reducing inventory. By the use of standardized materials, the stock can be available for a larger variety of requirements. Another advantage of standardization is an increase in the ability to secure materials in the local market. Thus, a reduction is realized in the investment, with a consequent saving of interest in manufacturing materials for a given output. Also the maintenance and distribution of stocks are rendered less costly, and the storage equipment and space required are decreased. With decreased and faster moving inventory of standard stocks, there is less tendency toward frozen stock, with the attendant deterioration, obsolescence, and eventual scrapping, because of its special nature. Simplification also reduces the number of records necessary for stocking materials and produces more effective stock control.

Standardization minimizes private stocks of material accumulated by operating departments, because of the endless trouble and confusion of procuring these items as required in smaller amounts.

By providing for the description of efficient packing, shipping, and marking, material specifications reduce the receiving and handling costs at the consumer's plant.

MANUFACTURING DEPARTMENT

Standards of accomplishment are dependent upon standards of materials, as well as of equipment, methods, and products. There can be no standard or uniformity of accomplishment without standardization of all of the conditions under which the work is done. The tremendous burden placed upon manufacturing departments of overseeing the great multiplicity of materials is sometimes overlooked.

A program of material standardization will reduce the total number of types or cycles of manufacturing processes required, and, naturally, this will result in more efficient labor due to skill increased by repetitive process. The materials supplied to the manufacturing department will be improved and of more consistent uniform quality, as described under the heading, "Production."

Manufacturers. Simplification and standard purchasing specifications have corresponding advantages for the producer which are, naturally, indirectly of advantage to the consumer.

For essentially the same purpose, the vendor is not compelled to supply materials ordered to a variety of specifications which may differ by just enough to require costly change-overs and separate production under each, involving many classifications in production, in stock files, and the like, with no commensurate benefits to the user. With a single standard specification instead of many, quantity production is possible, together with a reduction in overhead charges, particularly those arising from the duplication of machinery, the cost of testing, and the rent of storage space, resulting in increased economy. By concentrating on fewer lines, it allows more thought and energy to be put into the standard materials, thus favoring an improvement in quality. When the manufacturer is operating at capacity, simplification will permit the mills to get out products without being handicapped by the delays incidental to processing small batches of material to suit unnecessary specifications.

A less obvious advantage of simplification is the stabilization of production and employment which it insures. Given a reasonable measure of agreed standardization on a national scale, producers can, in times of seasonal or other slackness, manufacture for stock with some degree of assurance that their production will find a market in times of peak demand. When it is possible to manufacture for stock without fear of obsolescence it also speeds deliveries and makes it unnecessary to rush through production with attendant overtime costs.

The producer by means of the purchase specifications knows exactly what he is expected to furnish and how the material will be tested and inspected by the consumer, thus reducing to a minimum the possibility of misunderstandings which are both vexatious and expensive. Also a better understanding is promoted by the consumer of the producer's problems through discussion during the process of setting up the specification requirements. Expenses to the vendor, caused by the trial-and-error method of setting up to make materials suitable for a specific part or use, are reduced. The specifications, furthermore, tell the vendor exactly how material shall be packed and

(*Continued on page 554*)

SPREADER STOKERS
Applied to MARINE BOILERS

By OTTO de LORENZI

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IN THESE days of war effort, ever-increasing demands are made on transportation systems to speed up the flow of essential raw materials. A very considerable part of this effort is contributed by the ore-carrying fleets operating on the Great Lakes. Because additional units for these fleets cannot be built overnight, the existing equipment must be operated on tight schedules and with a minimum outage for repairs during the season. Furthermore, experienced engine- and boiler-room operators are not readily available, and therefore it is necessary to have arrangements that require a relatively small crew. The application of mechanical stokers to shipboard boilers is one of the principal means of meeting some of these "speed-up" requirements.

The mechanical stoking of boilers on the Great Lakes is not new, since stokers were first used in this area some 40 years ago. However, it was not until 1930, with the introduction of the modern forced-draft type of spreader stoker, that it was possible to obtain anything like satisfactory performance. Previous to that time various types of underfeed, chain-grate, and overfeed stokers had been tried, but were found to be too sluggish for the load conditions encountered. Pulverized coal was also tried, but because of long periods of light load, when in port, auxiliary oil burners were required to maintain ignition, and the furnaces were too small for satisfactory combustion conditions under normal load.

Perhaps at this point consideration should be given to the conditions under which it is required to operate these boilers aboard ore carriers. When under way the steam demand is essentially uniform since the engines run at constant speed. However, when maneuvering in narrow waters such as rivers, locks, and harbors, there are extreme load fluctuations ranging from no load to full speed ahead or astern. While in port there are long periods of very light intermittent load. Bunker fuel may be taken on at any one of a number of ports. It may vary greatly in analysis and sizing. Because of the foregoing conditions, it is necessary to provide fuel-burning equipment that will promptly respond to wide load swings with little or no manual attention. This equipment must also be capable of handling fuel that may run from highly caking or coking to free-burning characteristics; from low to high fusion temperatures of ash; and also a relatively wide size variation due to changing percentages of lump and fines. It has been found that the forced-draft spreader type of stoker is best able to meet all of these extremes with consistently uniform and efficient results.

DETAILS OF MODERN SPREADER STOKER

The modern spreader stoker consists essentially of one or more units mounted on a cast-iron front, each comprising a coal hopper, a feeder which regulates the flow of coal in proportion to the load, and a distributor rotor which throws the coal into the furnace and distributes it on the grate.

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The design of the coal feeder is of utmost importance, for upon it depends the uniformity with which it is necessary to regulate the supply of fuel to the distributor. When coal is fine and dry it will tend to feed too rapidly. When wet the particles will tend to cohere or stick to the feeder, and thus may be supplied to the distributor in slugs. For these extreme conditions the rotary feeder provides more positive control of the amount of coal fed than any other available design type. The feeder shaft is driven by an adjustable, totally enclosed, double-acting ratchet mechanism, which permits positive regulation of coal feed over a wide range by either manual or automatic control.

The coal is measured out by the feeder at a rate necessary to carry the boiler load. It then falls in a practically continuous stream into the path of the distributor-unit blades. These blades are mounted in four rows parallel with the axis of the distributor rotor. Opposing rows have the blades set at an

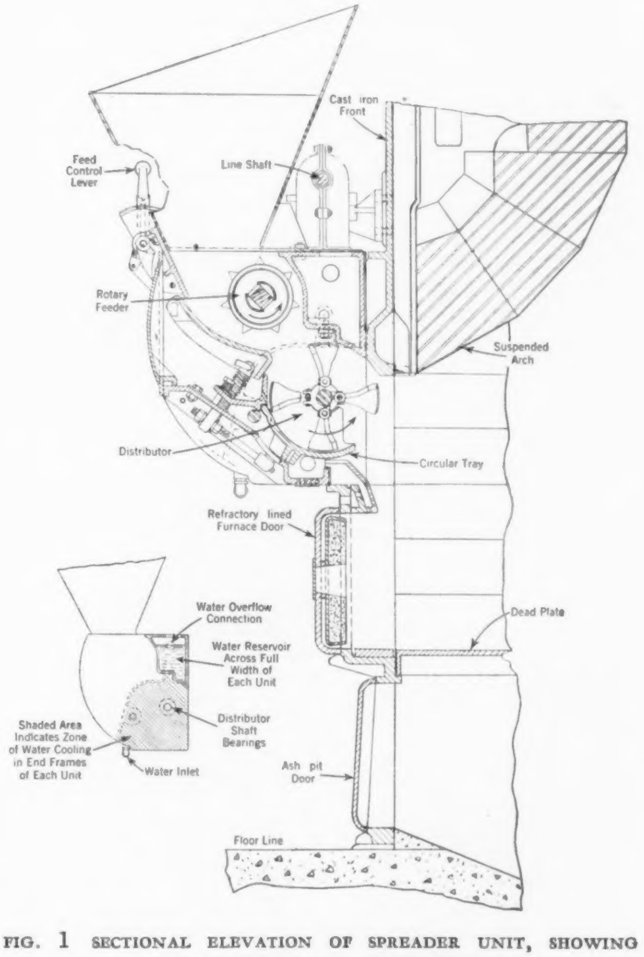

FIG. 1 SECTIONAL ELEVATION OF SPREADER UNIT, SHOWING ROTARY FEEDER AND DISTRIBUTOR

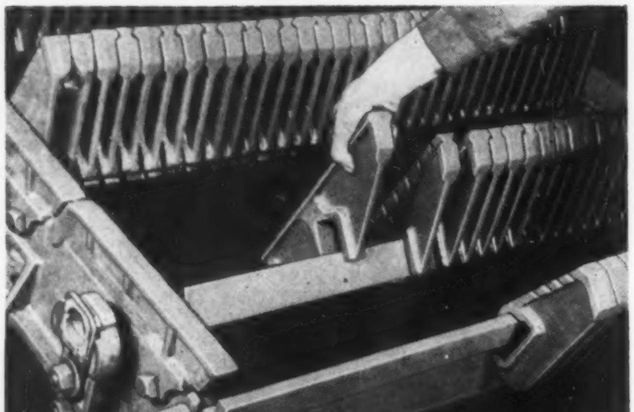

FIG. 2 GRATES IN DUMPING POSITION, SHOWING CONSTRUCTION DETAILS AND METHOD OF REPLACEMENT

angle that throws the coal to the right, and the alternate opposing rows are arranged similarly, but to throw toward the left. This crisscrossing of fuel streams results in consistently uniform distribution of fuel to the grate. The lateral distribution is determined by the angularity of the blades. The distributor speed determines the distance the coal is thrown into the furnace. To permit necessary adjustments in speed, that may be necessary because of changing fuel characteristics and operating conditions, a variable-speed mechanism is provided between the stoker drive motor and the main drive shaft. A feeder design incorporating the foregoing features is shown in Fig. 1.

The stoker grates may be either stationary or of the dumping type. The individual grate elements may be any one of several designs. However, it has been found that a surface which comprises a series of small-ribbed self-adjusting castings, overlapping at the end and sides, is most effective. These individual elements are mounted edgewise, side by side, on carrier bars, Fig. 2. This same design has been used successfully, for many years, on forced-draft traveling-grate stokers for burning such small-sized fuels as No. 4 anthracite buck, and river coal. This construction provides a deep rib under each small grate element so that the ratio of cooling surface to heat-absorbing surface is high. Long life of the grate is assured and then when repairs are necessary, they are limited to small inexpensive castings.

A forced-draft fan supplies the air to the fuel through a plenum chamber under the grate. The grate as well as plenum chamber are sectionalized laterally, corresponding to the number of feeder units. Each air zone is under individual damper control and therefore fires can be cleaned one section at a time. The depth of ash on a spreader-stoker grate will vary from zero, immediately after the fire is cleaned, to 4 in. or more, immediately before cleaning. The resistance to air flow becomes greater as the thickness of accumulated ash increases. However, the effect of the comparatively wide variation in fuel- and ash-bed resistance is minimized by restricting the air openings in the grate surface so that they represent from 2 to 3 per cent of the total area. By so doing, a high fixed resistance through the grate is provided, plus a comparatively low variable resistance through the ash layer. Thus, the variation in ash layer presents no problem in the practical application of automatic control.

An outstanding characteristic of the spreader stoker is its ability to burn a wide variety of coals. Because of the relatively thin, active, nonagitated fuel bed, strongly caking coals show little tendency to coalesce or to form coke masses during the combustion process, but burn with substantially the same characteristics as coals classed as "free-burning." Under proper operating conditions, there is never more than 2 or 3 min supply of coal on the grate. This thin active fuel bed lies on a cooled, nonagitated ash bed, and as a result of these conditions, few or no clinkers are formed, even though the fusion temperature of the ash may be very low. Minor adjustments to distributor speed and coal and air controls enable the furnace to respond quickly to wide variations in coal characteristics and sizing.

The adaptability of the spreader stoker to variations in fuel characteristics is an indication of its extreme flexibility and the ease with which it may be controlled to meet extremely fluctuating load conditions. Because of the very thin active fuel bed and the ability to change coal-feeding rate and air supply instantly to meet steam demands as they occur, there is less likelihood of "over-running" than with stokers carrying thick fuel beds. To take full advantage of the response characteristics, adequate automatic control equipment should be installed. The installation of such equipment should be rugged and simple, consisting essentially of a furnace-draft regulator

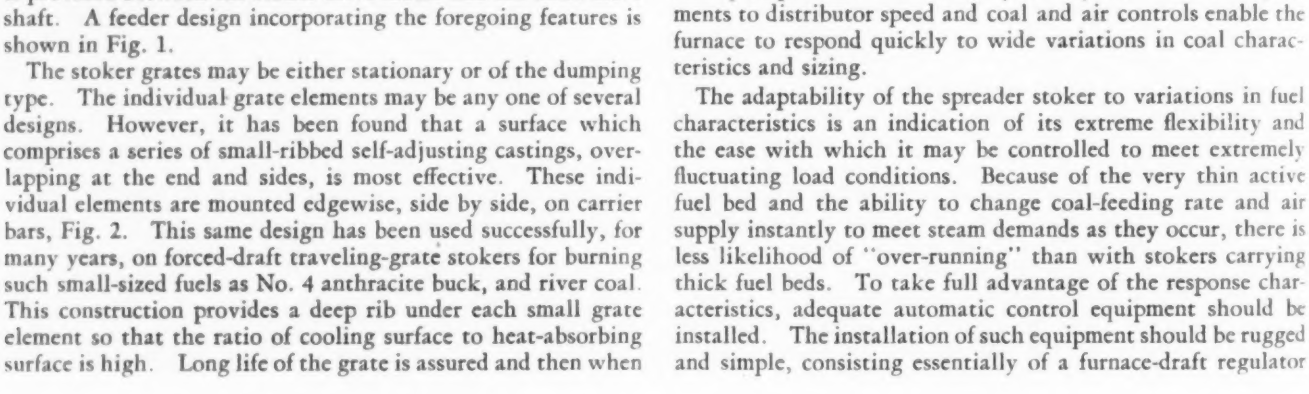

FIG. 3 SCOTCH MARINE BOILER FITTED WITH TWO-UNIT SPREADER STOKER

and a master regulator, actuated by steam demand, to control air and coal supply. Provisions are usually made in the stoker-operating mechanism for intermediate adjustments or for change-over to manual operation, should this seem to be desirable.

The low maintenance record of the spreader stoker is due to the inherent design which comprises simple elements and with all moving parts located outside the furnace. In this position these vital parts are relatively cool and readily accessible for inspection, adjustment, and lubrication. As an additional precautionary measure, certain sections of the mechanism are water-jacketed. The grate surface is flat with no parts projecting into the fire. The furnace is composed of straight, vertical walls with no arch or special construction. In addition to the quality of low maintenance, these factors are also instrumental in keeping the cost of installation to a reasonably low figure.

SPREADER STOKERS IMPROVE SCOTCH MARINE BOILER OPERATION

The Scotch marine type of boiler is used on a large number of vessels of the ore-carrying fleets. It is a good steamer, producing a relatively low exit-gas temperature. It is compact and, since there is an almost total absence of refractory, has very little furnace maintenance to contend with. On the other hand, the furnaces, generally two or three per boiler, are quite limited in volume and therefore not conducive to the best combustion results. The arrangement of furnaces frequently is such that the task of firing and pulling ashes is an arduous one. The application of steam superheaters and tubular air preheaters to boilers of this type served to improve conditions somewhat since the coal burned per indicated horsepower is reduced. The greatest improvement made, however, came with the application of spreader stokers, since by this means the fireman was better able to give more attention to maintaining proper furnace conditions. The fact that over twenty vessels equipped with spreader-stoker-fired Scotch marine boilers now operate on the Great Lakes is an indication of the soundness of this type of firing.

Fig. 3 shows one of the more recent applications of this type. In this instance, there are two 258-hp boilers, with two 54-in. furnaces per boiler. Each furnace is provided with a grate having a width of 4 ft and an active length of 7 ft. The effective furnace volume in front of the bridge wall is 71 cu ft, or a total of 142 cu ft per boiler. The total furnace volume, including the upper part of the back combustion chamber, is 345 cu ft per boiler. The boiler operates at 190 lb gage and 630 F at the superheater outlet. An air preheater is located in the uptake flue. Under normal steaming conditions, approximately 750 lb of coal per hr is burned in each furnace. This represents a heat-release rate, in the primary furnace, of 144,000 Btu per cu ft. However, since combustion continues in the back connection, the release rate is reduced to 59,000 Btu per cu ft when the total furnace volume is considered. This is a reasonable rate because the furnace and combustion chamber are completely water-cooled, with the result that furnace temperature is maintained at a low level.

In the installation illustrated, to borrow a recently coined phrase, "something new has been added." It will be noted that a cinder-return system has been provided in order readily and quickly to remove accumulations which are deposited in the lower portion of the combustion chamber. These returns are injected into the plenum chamber below the grate. From here they may be removed manually and returned to the stoker hopper, or rejected overboard when the ashes are pulled. This additional feature assists in making the job of the fireman just a little less difficult. The usual method is to remove manually these accumulations from the combustion chamber during periods when it is possible to draw the fires for a short time.

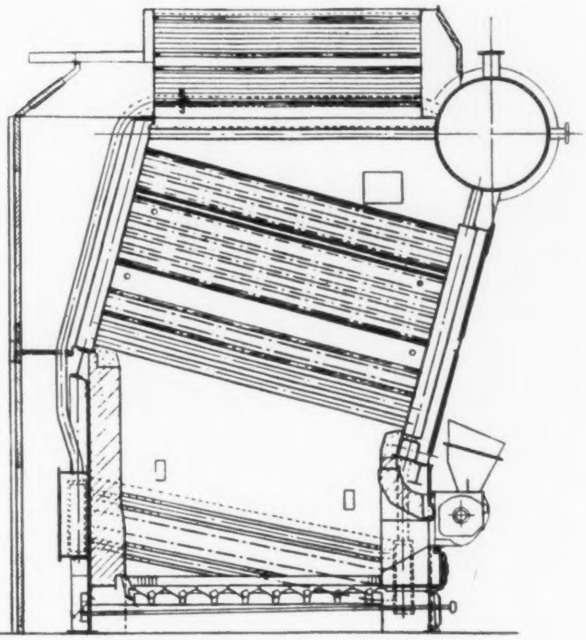

FIG. 4 MARINE-TYPE SECTIONAL-HEADER BOILER WITH WATER-COOLED FURNACE AND SPREADER STOKER

APPLICATION TO SECTIONAL-HEADER BOILERS

The steam-generating unit, shown in Fig. 4, is of the type used in most of the present-day refitting jobs and in some types of vessels now under construction. It consists essentially of a sectional-header boiler of the single-pass type, equipped with superheater, tubular air heater, waterwalls, and spreader stoker. It is compact, fully accessible, easy to operate, flexible, and capable of high sustained efficiency. In the case of Great Lakes carriers, there are usually two of these units, each having a normal capacity of approximately 16,000 lb and a peak capacity of 20,000 lb of steam per hr, with a pressure of 195 lb and a temperature of 440 F at the superheater outlet. In the unit shown, the furnace volume is 435 cu ft and stoker grate area 63 sq ft. The boiler is of the cross-drum sectional-header type in which the first two rows of tubes are 4 in. OD. The next four rows are 2 in. OD, and the top 22 rows are $1^1/_4$ in. OD. One row of 4-in-OD circulators connects the upper ends of the uptake headers to the steam off take drum.

By using an arrangement of this type, it is possible to install a large amount of heat-absorbing surface compactly and yet encounter relatively low draft loss. The superheater is installed in an interdeck space above the 2-in-diam tube bank. The saturated- and superheated-steam headers are located on one side of the boiler. They have the same slope as the boiler-tube bank. In this position, the element ends are easily observed and the entire superheater is readily accessible should it require attention. The water-cooled surfaces forming the furnace side walls consist of 10 rows of tubes provided with extended surface in the form of electrically welded fins. With this type of construction, there is practically no exposed refractory in these side walls. The front and rear walls are of the usual refractory-type construction. A tubular air heater is located directly above and in close proximity to the boiler. The flue gases make a single pass over the tube surface. The air, however, enters the upper half of the preheater tubes and flows across and is returned to the rear of the boiler through the tubes in the lower section of the tube bank. This provides

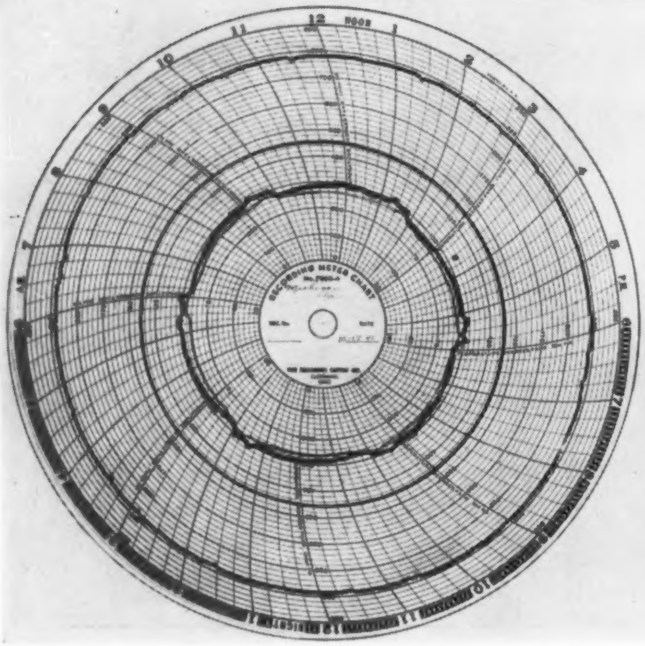

FIG. 5(*a*) CHART SHOWING TEMPERATURE RECORD ON LOADED RUN DOWN LAKE MICHIGAN

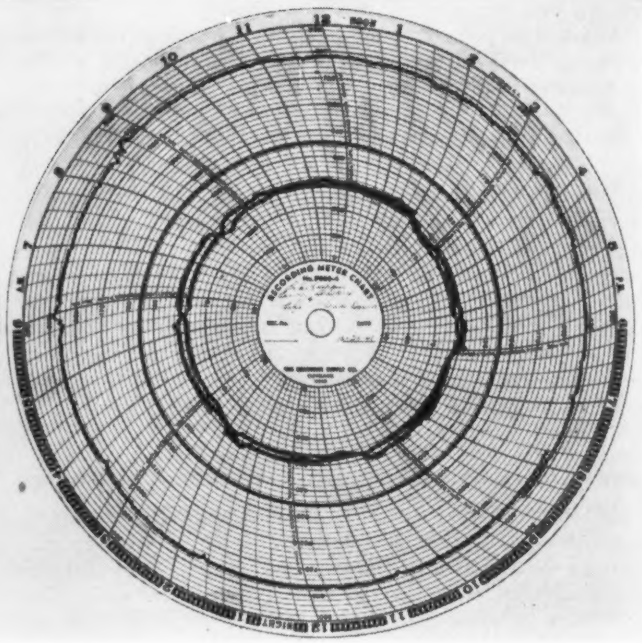

FIG. 5(*b*) CHART OF LOADED RUN DOWN LAKE HURON, LOWER RIVERS, AND LAKE ERIE

a counterflow effect and increases the heat-absorption rate quite materially. The rear outer casing of the boiler is so arranged that together with the boiler header and rear furnace wall it forms the air duct connecting the preheater to the stoker plenum chamber. This gives a very compact arrangement, requiring very little space.

The stokers are of the spreader type, using two feeder units per boiler. The grate may be of the stationary or dumping type, depending on the space available for ash disposal. Overfire air nozzles, under damper control, are located in the rear furnace wall. This design feature makes it possible to increase furnace turbulence and speed up the combustion process. A fly-ash return system is used to return to the furnace any siftings that may accumulate in the cinder traps. The operation of this system also increases furnace turbulence and improves efficiency, because it returns to the furnace unburned carbon that would otherwise be lost up the stack.

Generally, when under way or standing by in port, both steam-generating units are maintained in service. Normal operation is no particular problem, since all of the feeder units are in operation and the combustion rate on the stokers may be between 20 and 30 lb per sq ft of grate per hr. When in port very little steam is required and the actual combustion rate may be as low as 5 lb per sq ft per hr. Obviously, at this low rate control would normally be quite difficult. However, this is easily overcome by operating only one feeder unit per boiler, thus keeping the combustion rate on the section of grate used up to approximately 10 lb per sq ft per hr. In this way it is quite possible to control the fuel bed readily, so there is no difficulty in meeting any demand changes that may occur.

OPERATING RESULTS WITH SPREADER STOKERS

Perhaps the best illustration of the operation of these stoker-fired units is the series of charts reproduced in Fig. 5. The recordings shown on all of these are as follows: The outer line shows feedwater temperature averaging about 220 F; the middle lines show steam temperature at the superheater outlet, averaging about 450 F; and the inner pair of lines show outlet-gas temperatures from starboard and port boilers averaging about 280 F. These charts have been selected at random so as to cover the normal operating conditions encountered. An inspection will immediately show a disturbance in the outlet-gas-temperature curve on all charts at regular intervals. These are the periods when fires are cleaned and soot is blown from the boiler tubes. This work is faithfully carried out by the fireroom crew at 1:20 to 2:00, 5:20 to 6:00, and 9:20 to 10:00 a.m. and p.m. There is an exception to this routine in the case of charts Fig. 5(*b*), when soot blowing was omitted at 9:20 a.m. and 1:20 p.m. in Fig. 5(*d*). The reason for this omission was that in the first instance the vessel was passing through the Detroit River, and in the second instance it was docked at Two Harbors, Minn.

Fig. 5(*a*) shows typical performance during a constant run without interruption down Lake Michigan. It will be noted that the steam temperature is constant throughout the entire run. The boiler-exit-gas temperature indicates that there was no checking of speed or maneuvering during this part of the trip.

Fig. 5(*b*) is the record of a run through Lake Huron, Lower Rivers, and Lake Erie. Again the steam temperature is constant even though there is checking of speed when entering the rivers at 7:50 a.m. and resuming speed at 8:10 a.m.

Fig. 5(*c*) is the record of a run up Lake Michigan through the Straits of Mackinac, and then through the Soo Locks. On entering the Mackinac Straits at 8:25 a.m. the speed was checked and then resumed at 9:20 a.m. During this interval the steam temperature dropped from 450 F to 420 F, but rose with the firing rate as speed was resumed. The Soo Locks were entered at 1:45 p.m. and speed checked. Here again, the steam temperature dropped, but rose on leaving the locks at 2:20 p.m.

Fig. 5(*d*) is the record of a run up Lake Superior to Two Harbors, Minn., where the boat was docked for loading at 9:50 a.m. The return trip down Superior started at 2:00 p.m. During this 5-hr loading period, the boilers were operated to supply service steam only. As a result, the steam temperature dropped to 420 F. It immediately rose to normal when the boat steamed away on its return trip.

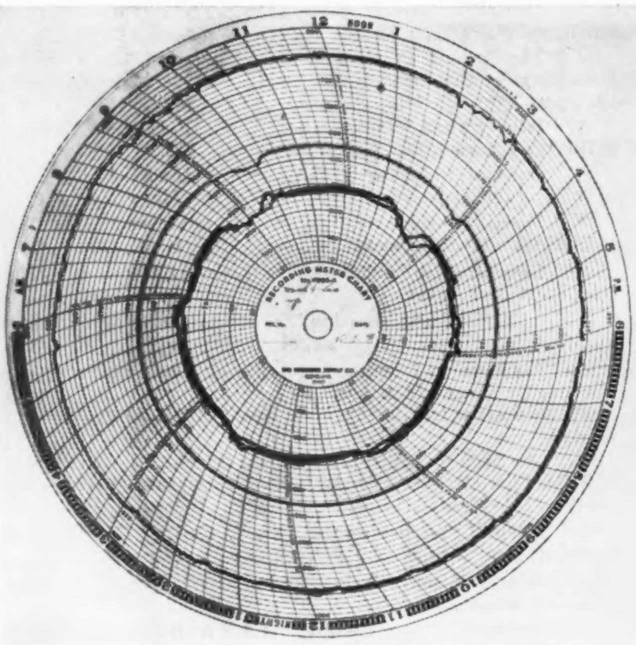

FIG. 5(c) CHART OF LIGHT RUN UP LAKE MICHIGAN, THE SOO, AND LAKE SUPERIOR

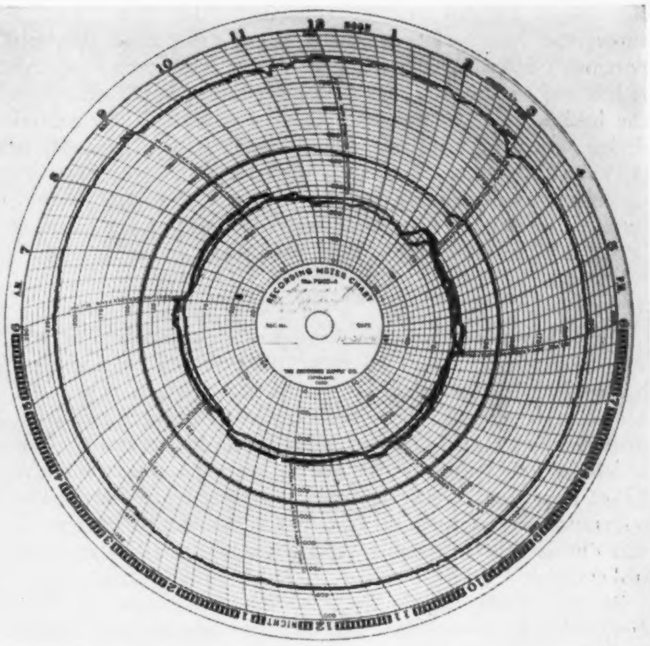

FIG. 5(d) CHART OF LIGHT RUN UP LAKE SUPERIOR, LOADING PERIOD AT TWO HARBORS, MINN., AND LOADED RUN DOWN LAKE SUPERIOR

This series of charts is certainly an indication of efficient operation, as well as of exceptional performance of the fuel-burning and steam-generating equipment. In studying these charts it should be remembered that undoubtedly there was a variation in the bunker fuel, since it was taken aboard at no less than three different ports. The constant steam-temperature lines show that boiler-water conditions are excellently maintained. The vessel from which these charts were obtained is equipped with reciprocating engines and jet condensers, and therefore raw water is used for boiler feed. A continual check enables the engineer to treat the water chemically. Periodic blowdowns, the frequency of which is dictated by analysis, maintains the concentration below a level which insures low moisture in the steam. The constant steam-temperature recording indicates the correctness of the boiler-water conditioning.

TABLE 1 MODERN STOKER INSTALLATION ON GREAT LAKES ORE CARRIER

Design Data

Boiler heating surface, sq ft	4830	Furnace volume, cu ft	410
Waterwall surface, sq ft	32	Evaporation, normal, lb per hr	16000
Air-heater surface, sq ft	2250	Evaporation, maximum, lb per hr	20000
Grate area, sq ft	64	Design pressure, psi	250

Test Results

Date—1941	August 23	August 27
Ship running	Light	Loaded
Number units tested	2	2
Duration of test, hr	8	8
Ship speed, mph	12.3	11.35
Main engine, rpm	87.6	85.1
Total horsepower	2157	2080
Steam pressure, superheater outlet, psi	195	195
Steam temperature, superheater outlet, F	453	453
Feedwater, temperature, F	230	226
CO_2, per cent	14.1	14.2
Gas temperature, air-heater outlet, F	266	272
Air temperature to air heater, F	101	107
Air temperature out of air heater, F	265	270
Furnace draft, in. H_2O	0.20	0.19
Uptake draft, in. H_2O	0.44	0.41
Coal, as fired, lb per hr	2961	2893
Coal, as fired, per hp	1.37	1.39
Coal, as fired, per sq ft grate surface	23.1	22.7
Furnace liberation, Btu per cu ft	48000	46800
Refuse from grate, lb per hr	196.2	192.2
Water to boilers, lb per hr	31545	31184
Total Btu in coal	39,300,000	38,400,000
Total Btu in steam	32,950,000	32,600,000
Efficiency, per cent	84.0	84.9

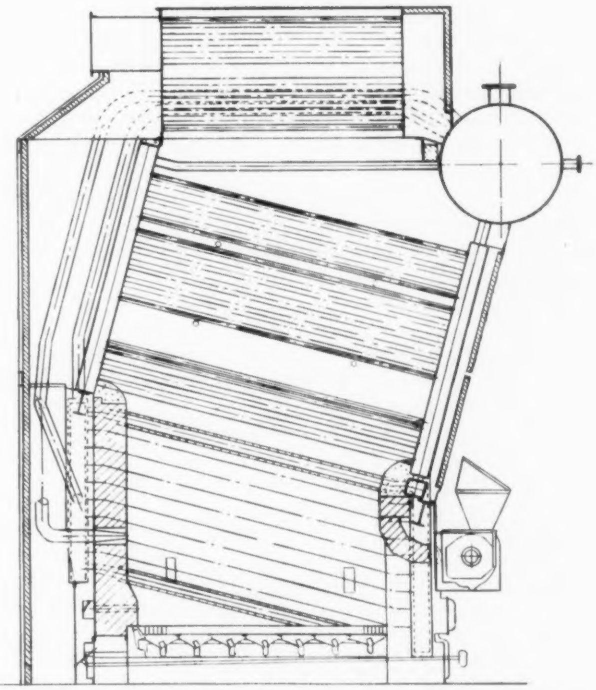

FIG. 6 MARINE-TYPE SECTIONAL-HEADER BOILER ON WHICH TEST RESULTS SHOWN IN TABLE 1 WERE OBTAINED

During August, 1941, tests were conducted on two units aboard one of the ore carriers. These tests were made during

the "light" uprun and the "loaded" downrun. Fig. 6 shows the design of these units. They differ from the unit previously described in that the amount of furnace-wall cooling is less and the overfire air- and cinder-return nozzles through the bridge wall are omitted. Table 1 contains the essential design data as well as the test results. These tests substantiate the excellent results indicated by the series of charts previously discussed. An efficiency of 84 per cent and higher with a furnace liberation of approximately 47,000 Btu per cu ft is better than average in any stoker-fired plant ashore or afloat.

PERSONNEL REACTION FAVORABLE

Over forty vessels are now equipped with spreader stokers; approximately one half of these have Scotch marine type boilers, while the balance are of the water-tube type. An additional twenty or more ore carriers to be equipped with stokers are now being refitted or are under construction. This is definite indication that the general feeling among the Great Lakes operators is now favorable to spreader stokers. The reluctance with which they at first accepted this equipment was due largely to trouble experienced with earlier types of stokers.

Because of unfavorable fireroom surroundings, due to dust, dirt, and poor furnace conditions, there was a frequent "turnover" of firemen. It was necessary constantly to "break in" new firemen, and this fell to the lot of the second engineer. Even though exceptionally capable and conscientious, it was difficult to develop the fireroom crew into an efficient unit. However, when it was found that the spreader stoker had an inherent reliability, and that it was easy to adjust and operate, good firemen were attracted to boats so equipped. It was possible to keep up steam with much less labor. The development of compact and reliable coal-and-ash-handling equipment and its installation in many stoker-fired vessels further improved operating conditions. The boiler room may now be as clean and comfortable as the engine room. The fireman, in many cases now called stokerman, has a job which compares favorably with that of the oiler. The turnover in fireroom labor has been greatly reduced, to the mutual advantage of owner and crew.

Benefits of Material Standardization

(*Continued from page 548*)

marked, with consequent saving in time required for checking and handling.

By enabling the buyer and seller to speak the same language, fairness in competition is thus promoted since bids can be made on an easily comparable basis. The purchase specifications tend to provide open markets through nonrecognition of trade names or fancied superiority of branded products. Thus a protection is provided to the reputable manufacturer who otherwise might be in competition with manufacturers of inferior products without the differences in quality being apparent.

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Design-Strengthened Materials

GENERALLY accepted methods for increasing the strength of light structural sections usually increase the weight per square foot. The design-strengthening of annealed and cold-rolled stainless steel and low-alloy steel, sheet or strip, reduces the weight per square foot. This new process consists of scientifically and accurately redistributing the material through the cross section and on the surface away from the neutral axis, beyond the limits of plain cold-reduced material, to impart increased strength-weight ratios to light sections. It is accomplished by rolling the sheet and strip through specially prepared rolls having on their surfaces a design that is transferred to either the top or bottom surface of the sheet or strip, or to both surfaces. By varying the pattern on the rolls an unlimited number of different design-strengthened surfaces can be applied to sheet and strip to improve the strength in both the longitudinal and transverse directions to rolling.

Design-strengthened sheets and strip have high tensile strength with good ductility, which is important from the standpoint of the fabrication of lightweight high-strength structures. Formed shapes of the sheets and strip strengthened by this process have high compressive strength, and greater stiffness than similar shapes made from either plain or cold-rolled material. The principal advantages of the process for lightweight high-strength structures are: increased rigidity, buckling strength, and possibly effective modulus. These advantages are obtainable on a wide variety of materials used under a wide variety of conditions, which makes the process applicable in most lightweight structures required to withstand high stresses.

COMMENTS ON PAPERS

Including Letters From Readers on Miscellaneous Subjects

White Burley Tobacco

Comment by Minott Brooke[1]

Not only in the case of the section growing White Burley tobacco, but in other localities we have endeavored to promote the use of coal in the curing process. The wealth of information included in this paper[2] is of genuine interest to the writer because of the fact that he has "raised" a crop, using a general local expression, and has been sufficiently interested in Burley tobacco to inquire each season as to comparative qualities and prices.

Those intimately acquainted with the production of tobacco agree that the majority of the growers will quickly change to any curing method which shows promise of improving or guaranteeing the quality of their salable tobacco.

Another new use of coal as fuel as outlined in this paper is of primary interest. It is fortunate for all concerned that the high-quality coals of the Appalachian region lie between two areas which produce more than 80 per cent of all the tobacco grown in the United States. The production statistics in Table 1 are from a report[3] of the U. S. Department of Agriculture.

Section of Virginia and North Carolina, the coastal section of North and South Carolina, southern Georgia, and northern Florida. A great deal of investigation and experimentation is being carried on by the U. S. Department of Agriculture, the Tobacco Experiment Stations of North Carolina, and others interested in flue-cured tobacco. It is well known that flue-cured tobacco in the areas mentioned is cured in barns by the application of heat from furnaces. Wood was formerly the only source of fuel but today all types of fuels are being used.

Domestic underfeed stokers and coal are admirably suited for supplying the source of controlled heat necessary for the successful coloring and curing of the leaf tobacco. Several such installations have been inspected and have been reported as being very satisfactory by the growers. While the curing process of this tobacco is somewhat different from White Burley tobacco, it is usually estimated that 1 lb of coal is required for each pound of flue-cured tobacco. Since the average production of this class of tobacco for the 5 years, 1935 to 1939, was approximately 861,000,000 pounds annually, another sizable potential market for coal exists in this tobacco-growing area. The potential tonnage of this market is approximately 430,000 tons annually.

TABLE 1 ANNUAL PRODUCTION OF TOBACCO

	Total, lb				
Year	Light, air-cured, types 31-32	Flue-cured, types 11-14	Types 11-14, 31-32	Per cent of total	All types, total, lb
1935	249,598,000	811,195,000	1,060,793,000	82	1,297,155,000
1936	250,380,000	682,850,000	933,230,000	81	1,155,328,000
1937	425,167,000	866,302,000	1,291,469,000	82	1,562,886,000
1938	368,606,000	785,731,000	1,154,337,000	83	1,375,823,000
1939	424,594,000	1,159,320,000	1,583,914,000	86	1,848,654,000

It has been noted that the potential market for coal for all purposes for which fuel is used today in producing Burley tobacco is approximately 305,000 tons annually. Flue-cured tobacco, types 11-12-13-14, is produced in the Piedmont

This, together with the coal and coke estimated to be used by the producers of Burley tobacco, represents a potential market of 735,000 tons annually. No doubt, a number of years will elapse before any appreciable tonnage will be realized by the coal industry from this potential market but, nevertheless, new uses for coal are vitally necessary to the industry.

The task before the engineer is to take the information from this paper and develop equipment that may serve a variety of purposes for the tobacco producers in various states. This is not an impossibility but will require study and imagination to solve the many problems. In some respects home-heating equipment as a basic unit probably offers some possibilities.

[1] Assistant Fuel Service Engineer, Chesapeake & Ohio Railway Company, Huntington, W. Va. Mem. A.S.M.E.

[2] "White Burley Tobacco—What the Engineer Should Know About Its Production," by L. S. O'Bannon, Mechanical Engineering, March, 1942, pp. 187-192.

[3] "Annual Report on Tobacco Statistics, 1940," U. S. Department of Agriculture, Sept., 1940.

Comment by W. H. Carrier[4]

This paper covers very thoroughly and clearly the possibilities of mechanization in the curing of Burley tobacco.

More than 20 years ago, the writer, in collaboration with A. C. Buensod, made extensive studies in the application of air conditioning to tobacco conditioning and processing. Several practical installations were made to demonstrate the commercial feasibility of air-conditioning applications in this field. As a result of this research, it was found that standard high-grade air-conditioning equipment, while greatly improving the quality and quantity of high-grade leaf in curing, did not have sufficient annual usage to pay suitable returns on the required investment. The conclusion was reached that, if air conditioning was ever to be successfully applied to curing barns, it would have to be in the nature of very crude, very cheap, low-grade agricultural-machinery type suitable for installation and operation by the average farmer. Such equipment would have to depend upon hand operation rather than upon automatic control.

In the stripping and sorting buildings, however, due to their greater time of usage, it was practicable to install standard air-conditioning equipment for the control of uniformity of high humidities suitable for putting and maintaining tobacco in the proper pliable condition for handling without breakage. It was proved that standard air-conditioning equipment for the control of humidification was profitable, especially in the larger warehouses.

An alternative mechanical equipment for curing tobacco was considered, comprising a portable conditioner with portable boiler or a direct-fired heater which could be used in the frequent emergencies

[4] Chairman of the Board, Carrier Corporation, Syracuse, N. Y. Mem. A.S.M.E.

that occur when the weather is so humid that injury to the tobacco is threatened. A portable unit would rectify these abnormal conditions in the barn within a short time and could be taken from barn to barn. One such unit might serve a dozen average-size barns. The same unit could also be used later for putting the tobacco in "case," i.e., by producing a high humidity in the barn giving the leaf the necessary moisture pickup or regain for pliability. This would be of great advantage at the time of the removal of the tobacco from the barns to the warehouses and independent of outside weather conditions. As it is now, they must wait for damp weather. It requires between 78 and 85 per cent relative humidity to put the tobacco in proper case. The margin of average relative humidity is even narrower in the curing of tobacco.

Tobacco, or any other leaf, when taken from the stem starts a respiration or ripening process in which moisture and carbon dioxide are given off. Starch in the leaf is turned to sugar and the sugar is further oxidized in the final curing. This respiration can go on in the leaf only while there is sufficient moisture in it. In other words, if the leaf is either artificially or naturally dried out by too low a humidity this respiration process is stopped. On the other hand, the rate at which free moisture is produced in the ripening process depends upon the condition and character of the leaf and upon the temperature, rather than upon the surrounding humidity. The ripening process and the rate at which moisture is given off doubles for about every 18- or 20-deg F rise in temperature, following the well-known law of chemical activity. The free moisture produced by the ripening process must be removed as fast as it is produced, but no faster. The accumulation of moisture within the cells, if not removed, will cause them to burst with consequent poleburn which darkens and ruins the tobacco. The accumulation of excess moisture on the outside of the leaf also has a similar darkening effect.

The point of equilibrium between the removal of free moisture as fast as it is formed and the excessive removal of moisture, which would lead to predrying of the leaf, lies in the very narrow band of relative humidity and requires ample air circulation, natural or artificial. This relative humidity is found to lie between 78 and 82 per cent. Considering this, it may seem almost miraculous that the farmer is able to cure tobacco satisfactorily in his barn at all. Then how is this extremely delicate regulation accomplished? Fortunately, good tobacco is more or less tough and can stand considerable deviation from such a rigorous standard for hours or even for a day or two providing one extreme condition is compensated by an opposite condition, in other words, if the condition of relative humidity averages up during the critical period of the cure.

The farmer has no hygrometer to guide him, and probably this is just as well. The leaf itself indicates whether it is suffering from too much moisture or too little and the farmer accordingly adjusts his ventilation to rectify this condition. He is only out of luck when the outside humidity is too high to obtain such control. Then he frequently must resort to low fires under the tobacco or other means of raising the temperature and producing circulation.

It is a remarkable fact that the experienced farmer, in normal weather conditions, can obtain a very excellent cure simply by watching the leaf and varying the ventilation in accordance with its indications. To accomplish the same result, independent of weather conditions and natural ventilation, would require a very fine and exceedingly accurately controlled air-conditioning plant. This rarely pays, even with the highest-priced tobacco, such as shade-grown wrapper tobacco. However, some simple means of producing artificial circulation with added heat when required and also some simple means of adding moisture to the air under extremely dry outside air conditions, probably can be made to pay. Such equipment, however, does not lie in the province of the manufacturer of high-grade air-conditioning equipment, but properly belongs in the field of the hot-air-furnace or agricultural-machinery manufacturer. It should embody little more than the cheapest type of motor- or engine-driven fan, and the lowest-priced warm-air furnace. Piping for distribution of the air could be put in by the local dealer or the farmer himself.

The design of such a low-cost installation is a proper subject for study by the State Agricultural Department. A low-cost plant could be made to pay for itself and would be a great boon to the farmer. He would depend under normal weather conditions on the natural ventilation in his barn, but would use the equipment to save his crop under unfavorable weather conditions. He would have to operate by the cut-and-try method, based on experience, just as in his present method of curing. It would probably not be wise to try to totally supplant natural curing by artificial curing, although this development may eventually come about with the experience in the use of such equipment. There are great advantages profitwise to be obtained by the tobacco farmer in the use of mechanical equipment, if a low-cost design can be developed for him. The field is not at all attractive from the standpoint of the manufacturer.

COMMENT BY R. R. TALIAFERRO[5]

This paper on White Burley tobacco grown in Kentucky brings out many interesting points concerning the importance of the tobacco crop in the economic structure of the state. The engineer specializing in air conditioning can contribute materially toward putting into practice the findings from the comprehensive research done at the Kentucky Agricultural Experiment Station. The farmer, the tobacco company, and every citizen of the state will benefit by the increase in the top quality of leaf resulting with controlled indoor weather in tobacco barns. Just as in other industries, the curing of tobacco follows the sequence of events as (*a*) determination of the optimum conditions for processing, (*b*) investigation to learn if the results of controlled conditions of air justify the expenditure for air-conditioning equipment, and (*c*) co-operation of the scientist, air-conditioning engineer, and the purchaser of the equipment for the proper relating of building design and mechanical equipment and results to be obtained.

From the statistics given in the paper, many interesting conclusions can be drawn. With 200,000 tobacco barns in Kentucky, an annual production of 218,000,000 lb of tobacco, and $47,000,000 annual income, the following averages may be calculated:

Each barn averages 1090 pounds of tobacco per year. Each barn averages $230 annual income per year. If air-conditioning the barns would increase the price of tobacco a few cents per pound, the annual income per average barn would not be materially increased.

Recognizing the distortion which average figures cause in presenting a picture, it is still quite evident that the annual income hardly justifies the purchase of mechanical equipment for air conditioning the average barn. With the farmer growing large crops of tobacco, the investment in air conditioning will be more attractive. However, it is the average farmer as well as the large farmer who should benefit by air conditioning.

The suggestion that, when not being used for air-conditioning the tobacco barn, the equipment will serve other purposes on the farm thus offers a way to extend the usefulness of the equipment throughout the year. But the effort to make the apparatus suitable to many pur-

[5] Carrier Corporation, Syracuse, N. Y.

poses may result in the "Jack of all trades" dilemma with the system being good at none.

A co-operative arrangement may be made so that all farmers can be served by one air-conditioning barn in the vicinity. Much as the locker storage plants serve the dairyman, produce farmer, and hog grower, so may an air-conditioned tobacco barn serve tobacco growers. As the low-temperature air-conditioned plant serves the farmer with cold storage, so may the community barn be air-conditioned to provide the farmer with top-quality tobacco for the market.

While saving in expense, as one large system can be installed and operated much less expensively than many small systems, the farmer can be assured of the optimum condition in the barn regardless of outdoor conditions. Nor does he have to make a large investment to derive the benefits of controlled indoor weather, if an adequate scientifically designed and equipped barn is near-by and available for his use.

When the author and his staff have completed the scientific research, which they are doing so thoroughly, and will make definite recommendations of the conditions of air that will best suit the tobacco, no doubt a progressive group of farmers will find the economic solution which will make it possible to install air-conditioning equipment to serve the majority of the tobacco growers. The air-conditioning engineer is already equipped to supply the apparatus that will give positive temperature, relative humidity, and circulation of air according to any recommendations made as a result of the test.

Author's Closure

The respective comments by Messrs. Brooke, Carrier, and Taliaferro constitute direct additions to the subject, for which the author wishes to express his thanks and appreciation. Some of the remarks, however, are not at all encouraging to one whose job is to find a practical solution to a problem, the solving of which it is admitted "would be a great boon to the farmer," but which, even after careful consideration, is doomed to the field of "very crude, very cheap, low-grade agricultural machinery." It is in situations of this sort, i.e., economically unfeasible—that the ingenuity of the engineer is frequently called upon; and the history of the profession bears a record of unending achievement among just such circumstances.

Mr. Carrier, true to his characteristic penetrativeness with regard to fundamentals, has given a good summary of some of the physiological aspects of the problem. However, he did not make clear the type of tobacco that had been used in his experiments. The author has consulted with his colleague, Dr. R. N. Jeffrey, plant physiologist in charge of the curing experiments, and it is believed that Mr. Carrier was discussing cigar tobacco, such as is grown in Connecticut and Pennsylvania and a few other regions, although his statement that the optimum relative humidity for curing lies between 78 and 82 per cent does not agree with the most recent publication of the Connecticut Agricultural Experiment Station.

The optimum relative humidity for White Burley lies between 65 and 70 per cent. Specifications for the best quality call for such characteristics as "light buff or straw color, very light or pale color shade, very clear or flashy finish, and tissuey or very tissuey body." These characteristics are not obtained if the relative humidity during curing averages over 70 per cent. In general, higher humidities will produce a darker, coarser tobacco which, in the case of White Burley, will bring a lower price. High humidities will injure White Burley even after it is well cured. Hence, in bringing the tobacco into case for stripping, it is advisable to use a relative humidity no higher than necessary. Seventy-five per cent has been found to be satisfactory for casing White Burley, although it is to be admitted that the 78 to 85 per cent, which Mr. Carrier states is required, would make the tobacco yet more pliable.

Mr. Carrier mentions tobacco, "when taken from the stem." This is not a process used in curing White Burley tobacco. He says also, "The free moisture produced by the ripening process must be removed as fast as it is produced, but no faster." This restriction would seem to have no significance with respect to White Burley because, as Dr. Jeffrey points out, less than 2 lb of water would be "produced by the ripening process," for each 100 lb of fresh tobacco, in the same time that about 70 lb of water originally present as water would be evaporated.

With regard to the main theme of the paper, the use of fuels in curing White Burley tobacco, the author probably did not make clear that the estimate of the potential fuel consumption given in the paper was based on the continuation of and the wider adoption of the best of present-day practices. The author meant to imply, without making a definite prediction, that the potential market might be increased several times if and when a satisfactory method is obtained in which the use of artificial heat as the primary means of controlling the conditions should become a routine practice every day of the curing season. As Mr. Taliaferro indicated in his analysis of the statistics, so far as one can see now the adoption of such a method would be practical for only the larger than average farms. The chief problem is to overcome the high cost which the use of equipment and methods available today would entail.

L. S. O'Bannon.[6]

[6] Research Engineer, Kentucky Agricultural Experiment Station, University of Kentucky, Lexington, Ky. Mem. A.S.M.E.

Unit for Heat-Transfer Rates

To the Editor:

The standardization of a heat-flow unit as advocated by Professor Lionel S. Marks[7] in the February, 1942, issue of Mechanical Engineering is highly desirable, as a general principle.

Professor Marks proposes that the watt with its multiplies and submultiples be adopted as the preferred unit in stating heat-transfer rates such as are now expressed as Btu per hour.

This suggestion will encounter some of the prejudices that militate against the general adoption of the metric system, however logical such a procedure may appear from a theoretical point of view, plus some other objections. Some of these possible thoughts follow:

1 Btu is firmly established as is Btu per hour. To supersede these units, a new unit would need to have overwhelming advantages.

2 A Btu defined as a mechanical equivalent of heat which varied with the experimenter (and consequently the date), was certainly objectionable. If the so-called A.S.M.E. Btu is adopted, the Btu is fixed as 778.26 ft-lb which obviates many of the objections to the older Btu's. Since this Btu is derived from the International Steam Table or IT gram-calorie it might more properly be termed the IT Btu.

3 Btu is a "mechanical-engineering" term and there will be considerable resistance to yielding to an "electrical" term such as the watt. This objection comes under the head of "prejudice."

4 A more serious inconvenience—if heat conductances expressed as watts per square foot are to take the place of

[7] "Unit for Heat-Transfer Rates," by Lionel S. Marks, Mechanical Engineering, vol. 64, February, 1942, p. 118.

Btu per square foot hour: Will heat quantities now expressed as Btu's, such as furnace inputs, be expressed as watt-hours? Will steam enthalpies and fuel calorific values be in watthours per pound instead of Btu per pound?

If the answer is yes, it is problematical whether watthours per pound is simpler than Btu (IT) per pound.

If the answer is no, then the boiler-furnace heat-transfer calculator supplying a furnace of x square feet with y pounds of coal per hour having z Btu per pound must compute not only that he is supplying yz/x Btu per sq ft hr, but he must convert to watts per hour. Later obtaining his heat absorptions in watts per hour he must reconvert in order to calculate steam evaporated unless the steam enthalpy is also given in watthours per pound.

5 Is it necessary to have one word such as watt to represent an energy flow rate instead of Btu per hour? Would this similarly imply that it might be desirable to have one word to represent the composite units Btu per sq ft hr or Btu per sq ft hr (F per ft), etc?

6 Engineers at the present are using more and more the units Btu and hour and square foot. It is suspected that the usage in connection with Btu of other units such as seconds, minutes, inches will gradually die out.

7 Few engineers indeed would object to using preferred composite heat-transfer units made up of Btu, foot, and hour. If the IT Btu were used such heat quantities would be as rigorously defined as if the watt were used.

H. F. MULLIKIN.[8]

[8] Analytical Engineer, Flushing, N. Y. Mem. A.S.M.E.

Manufacture and Processing of Aluminum

COMMENT by T. L. FRITZLEN[9]

This paper[10] has necessarily been limited, due to the scope of the subject covered, and there is one statement which might be interpreted ambiguously. The author states: "Except for very specialized cases of certain types of aluminum-alloy scrap, which is always fed into the remelting furnaces along with the virgin pig, little or no refining can be accomplished by the remelting operation." It is believed the author had in mind that impurities, such as iron and silicon, cannot be removed to any great extent by remelting, and did not mean that remelting does not accomplish refining by removal of included particles of electrolyte and oxide.

Since the engineer is vitally interested in the methods by which aluminum and aluminum alloys can be used to make much-needed items of defense, the following facts should be of general interest:

Aluminum and aluminum-alloy sheet can be bent, drawn, spun, or formed in almost any manner. The degree to which the sheet can be worked, employing these operations, naturally varies with the workability of the particular alloy and temper, e.g., 24S-T sheet cannot be formed with the same ease as 2S-O sheet.

Aluminum and most aluminum alloys possess good machining characteristics and, consequently, can be turned, milled or routed, sawed, drilled, and ground. Machining can be performed using the same tools that are used for machining steel, but better results are obtained using a modified tool similar, generally, to the tools used in woodworking. Type 17S-T rod and bar, both extruded and rolled, possess excellent machinability and are used extensively for screw-machine products.

Extruded and rolled rod and bar are used universally as forging stock, since aluminum-alloy forgings, as intricate as any made in steel, can be produced.

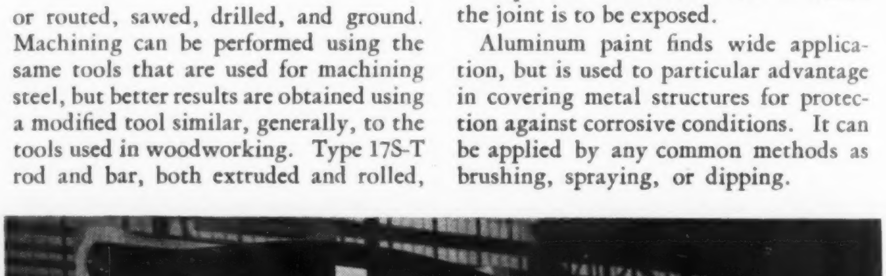
Aluminum and its alloys can be welded by either of the two general types of welding procedures used today; i.e., fusion welding, and pressure or resistance welding. Butt, lap, tee, and fillet joints can be made in aluminum in a manner similar to those made in other metals. Welding is, as yet, not used to the same extent as mechanical joining in the aircraft industry, since heating of the heat-treated aluminum alloy tends to soften it, thereby weakening the structure.

Other methods of joining aluminum and its alloys are riveting, soldering, and brazing. The particular method to be used for a given application depends upon the nature of the pieces to be joined, the cost of joining, the stress to be imposed and the conditions to which the joint is to be exposed.

Aluminum paint finds wide application, but is used to particular advantage in covering metal structures for protection against corrosive conditions. It can be applied by any common methods as brushing, spraying, or dipping.

[9] Reynolds Metals Company, Louisville, Ky.

[10] "Manufacture and Processing of Aluminum and Its Alloys," by Paul P. Zeigler, MECHANICAL ENGINEERING, February, 1942, pp. 106–108 and 131.



PROPELLER BLADES FROM SEAMLESS STEEL TUBING

(The tubing is transformed into blades by a series of hot-forging, cold-pressing, machining, and welding operations. The new steel blades are said to be lighter than aluminum in the larger sizes, have a greater resistance to corrosion and abrasion, and are the first to be made of a special chromium-molybdenum alloy which gives the blades better physical properties and increased fatigue strength.)

A.S.M.E. BOILER CODE

Interpretations

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Anyone desiring information on the application of the Code is requested to communicate with the Committee Secretary, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are then sent by the Secretary of the Committee to all of the members of the Committee. The interpretation in the form of a reply, is then prepared by the Committee and is passed upon at a regular meeting of the Committee.

This interpretation is later submitted to the Council of The American Society of Mechanical Engineers for approval after which it is issued to the inquirer and also published in MECHANICAL ENGINEERING.

Following is a record of the interpretations of this Committee formulated at the meeting of May 8, 1942, subsequently approved by the Council of The American Society of Mechanical Engineers.

CASE No. 934 (Reopened)

(*Special Ruling*)

Inquiry: Will unfired pressure vessels fabricated by fusion welding under the test requirements of Pars. U-69 and U-70 meet the Code provisions if the base metal is of copper conforming to Specifications S-20, S-21, S-22, or S-23, except that the material covered thereby is obtained in the deoxidized condition?

Reply: It is the opinion of the Committee that deoxidized copper material conforming to any of the above-mentioned specifications may be used for the construction of unfired pressure vessels by fusion welding under the general requirements of Pars. U-69 or U-70. For vessels constructed under either paragraph, the welding requirements of Par. U-69 and Section IX of the Code shall apply except that:

(1) One qualification test weld shall be made in the minimum thickness and one in the maximum thickness of material that will be used in construction;

(2) The elongation as determined by the free-bend test be not less than 30 per cent for Par. U-69 and not less than 20 per cent for Par. U-70 construction;

(3) Stress relieving is not required.

The rules of Par. U-20 shall be applied by using Table U-3 values for allowable working stress multiplied by:

(*a*) For Par. U-69 construction, 80 per cent joint efficiency;

(*b*) For Par. U-70 construction, the ratio of *SE* values given in Par. U-70(*a*) divided by 11,000.

CASE No. 935 (Reopened)

(*Special Ruling*)

Inquiry: Will unfired pressure vessels fabricated by fusion welding under the requirements of Pars. U-69 and U-70 meet the Code provisions if the base metal is annealed nickel-copper alloy material conforming to Specification S-54 (minimum tensile strength, 70,000 lb per sq in.)?

Reply: It is the opinion of the Committee that nickel-copper alloy plate and sheet conforming to the above-mentioned specification may be used for the construction of unfired pressure vessels by fusion welding under the general requirements of Pars. U-69 or U-70. For vessels constructed under either paragraph, the welding requirements of Par. U-69 and Section IX of the Code shall apply except that:

(1) One qualification test weld shall be made in the minimum thickness and one in the maximum thickness of material that will be used in construction;

(2) The elongation as determined by the free-bend test be not less than 30 per cent for Par. U-69 and not less than 20 per cent for Par. U-70 construction;

(3) Stress relieving is not required.

The rules of Par. U-20 shall be applied by using Table U-3 values for allowable working stress multiplied by:

(*a*) For Par. U-69 construction, 80 per cent joint efficiency;

(*b*) For Par. U-70 construction, the ratio of *SE* values given in Par. U-70(*a*) divided by 11,000.

CASE No. 968

(*In the hands of the Committee*)

CASE No. 969

(*Interpretation of Par. P-332*)

Inquiry: May superheater, waterwall, or economizer headers fabricated by a piping shop in possession of a pressure piping symbol stamp be identified as "part" under Par. P-332(*f*) using the pressure piping stamp?

Reply: It is the opinion of the Committee that parts of boilers that involve construction such as is covered by Par. P-112(*a*) (1) to (5), inclusive, when fabricated by a manufacturer in possession of the pressure piping symbol stamp and so stamped, may be covered by a Parts Data Form (form P-4). Such forms properly signed by the manufacturer and an inspector may be accepted by the inspector who certifies to the complete data form.

CASE No. 970 (*Special Ruling*)

Inquiry: May seamless casing conforming to A.P.I. Specification 5-A, eleventh edition, April, 1941, grades J-55 and N-80, Section III, be used for the construction of seamless vessels for noncorrosive stationary service at atmospheric temperatures, if designed in accordance with Par. U-140 with integral heads and with a maximum *S* factor of one fourth of the m nimum tensile strength?

Reply: It is the opinion of the Committee that seamless vessels built of this material may be stamped with the Code symbol, provided there are no stress raisers such as openings or stampings on the shell portion, and all outlet openings are located in the head portions where there is thickness available to reduce the calculated stress to one half or less of the maximum allowable stress. Inasmuch as the vessels are to be operated at atmospheric temperature, the impact test for low-temperature construction is not required.

CASE No. 971

(*In the hands of the Committee*)

CASE No. 972

(*Interpretation of Table Q-5*)

Inquiry: In the construction of unfired pressure vessels, may parts fabricated from dissimilar metals be joined by fusion welding?

Reply: Pressure parts made of dissimilar metals, both of which conform to specifications recognized by the Code, may be joined by fusion welding provided the procedure and the welding operators are qualified in accordance with the provisions of Section IX of the Code in so far as applicable and all the tests specified therein are applied to the required test specimens.

Where there is a marked difference in the flexibility of the metals being joined, the free-bend test may be replaced by a test procedure that will produce a bend similar to that obtained by the use of a guided-bend test jig, as shown in Fig. Q-19, with the weld approximately in the center of the bend; or the soundness of the weld may be determined by any other form of test that will reveal the completeness of penetration and fusion.

Sheet-Metal Working

THE E. W. Bliss Company, Brooklyn, New York, has prepared a new book entitled "Computations for Sheet-Metal-Working Operations" designed to assist in the solution of production problems of the sheet-metal worker. Chapter headings include Blanking and Shearing; Drawing and Reducing; Ironing; Coining, Sizing, and Forging; and Mechanical Press Selection.

In the working of metal in mechanical power presses it is often desirable or necessary to compute the pressure capacity and sustained-work capacity of the press as well as the pressure and work requirements of the job which the press is to do. A series of alignment diagrams for ease in making these computations has been prepared from such formulas as could be developed. Some of the formulas are theoretically accurate, others are empirical or are approximations which are sufficiently close for engineering purposes. The diagrams are discussed in groups; first the several types of operations performed upon metal, and later the capacities of the equipment.

Distribution will be made only to management, engineering, or production executives in the metalworking industry.

Plant Efficiency

WAR PRODUCTION BOARD

A BOOKLET entitled "Plant Efficiency—Ideas and Suggestions on Increasing Efficiency in Smaller Plants" has been published by the War Production Board and is now available for distribution, on request.

Chapters in the booklet deal with Good Lighting—Better Work; Cutting Down Accidents; Adapting Old Machines to New Jobs; Maintenance and Repair; Longer Life for Cutting Tools; Getting the Most Out of Machine Tools; Production Lines Geared for War; Meeting Government Standards; Training Workers Quickly; Swing Shifts; Keeping Track of Orders, Production, and Materials; Plant Protection; Pooling Facilities; A Word on Priorities; and Getting Into War Work.

Copies may be obtained from regional and local offices of the War Production Board, located in 120 cities; from local offices of the Division of Information, Office for Emergency Management; or by writing to the Division of Information, Office for Emergency Management, Washington, D. C.

National-Emergency Steels

WAR PRODUCTION BOARD

TECHNICAL information on the National-Emergency steels is accumulating and is being made available to industry. Increasing use of the steels has made them more readily available at steel mills and warehouses and numerous tests have been made. In addition, steel companies have been making physical tests on the new steels as they are produced.

To make the information available to industry, the Iron and Steel Institute has collected all existing data and published it in loose-leaf form. Included are curves showing the hardenability characteristics of all NE steels and the mechanical properties of a number of the compositions. Present data will be supplemented from time to time as testing of the steels continues.

National-Emergency steels are made in accordance with new specifications designed to conserve scarce alloying elements.

Snowflakes and Metallography

BECAUSE Vincent J. Schaefer, of the General Electric Research Laboratory, made a hobby of collecting plastic replicas of snowflakes, scientists now have a simple method of observing details of metal structure far too fine to be seen with the ordinary microscope. Naturally any observations which can tell more about metals, and possibly how to make them stronger and better, are of tremendous importance.

Ordinary microscopes, using light, magnify at the most some 2500 diameters. Increases of this figure are not possible, for then the details are too much smaller than the light waves with which they are viewed. This limitation is removed in the electron microscope where electrons act like waves of much shorter length which can be focused by electrostatic fields inside charged metal doughnuts or by magnetic fields formed by properly shaped magnets.

In this way, electron images, as much as 50 times the magnification of the best enlargement in light microscopes, can be made. The image is visible on a fluorescent screen, which shines where the electrons strike, or it can be recorded on a photographic plate. Electrons have little penetrating power, so the entire microscope must be exhausted of air. Also, the specimen being magnified must be very thin, otherwise the beam cannot get through. Unfortunately, samples of metal cannot be made thin enough to be examined in this way.

Complicated methods have been devised to eliminate this difficulty. One is to evaporate on the metal sample in a vacuum a thin film of silver and to reinforce this film by plating on the back another metal, like copper, so it can be stripped away. Then a very thin film of collodion is flowed over the silver and, after hardening, the whole silver-collodion-copper assembly is immersed in nitric acid. The silver and copper are dissolved away, but the collodion remains, a faithful replica of the original surface that can be examined in the electron beam. Experimenters who developed this method reported trying to strip a thin plastic film directly from the metal, but without particular success.

However, Mr. Schaefer, who has been associated for a number of years with Dr. Irving Langmuir in his work on thin films, had been reproducing minute details of snow and frost crystals by "casting" them in a film of Formvar. As a hobby, he has made a large collection of such crystal replicas, obtained during winter snowstorms, formed on glass on cold nights, or even made in the icebox in summertime. Before the electron microscope was introduced he had also made strippings from metal surfaces. Consequently, when an electron microscope was installed Mr. Schaefer's assistance was requested.

After some experimentation, he found why it had been difficult to get good films directly. Even with the most careful cleaning, a few grease molecules will soon settle on the surface, and these interfere with the removal of the film. This was overcome by cleaning the surface immediately before the film-forming material is applied. This consists of a solution of Formvar, a plastic, in dioxane, a commercial solvent. After the dioxane evaporates, the specimen is immersed in water, and the Formvar film, only a half millionth of an inch in thickness, is stripped away. Less than five minutes after the specimen is received from the polishing room, it can be examined in the electron microscope.

High places on the metal are thin spots on the Formvar film, while valleys come out as thick places. These scatter the electrons more and appear darker in the final image. This is also the way the specimens appear in the usual metallographic microscope, where high spots are light and valleys dark. Metallurgists accustomed to light photographs find that they can easily interpret the electron images.

FIG. 2 PHOTOGRAPH OF A METAL SPECIMEN MADE WITH THE USUAL TYPE OF MICROSCOPE

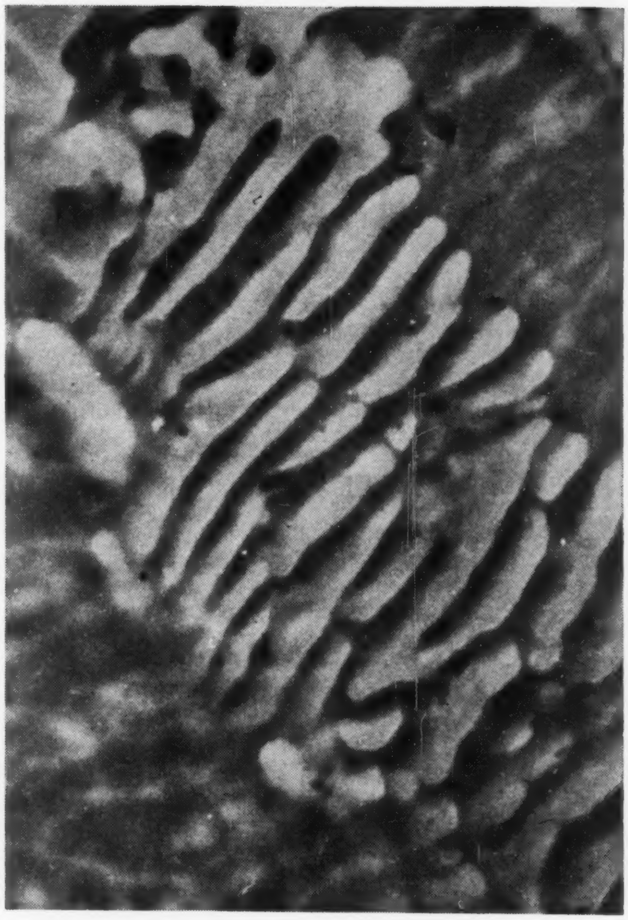


FIG. 3 AN ELECTRON MICROGRAPH OF SPECIMEN OF FIG. 2
(The magnification is many times that possible with the optical microscope. Fine details of metal structure never seen before are revealed.)

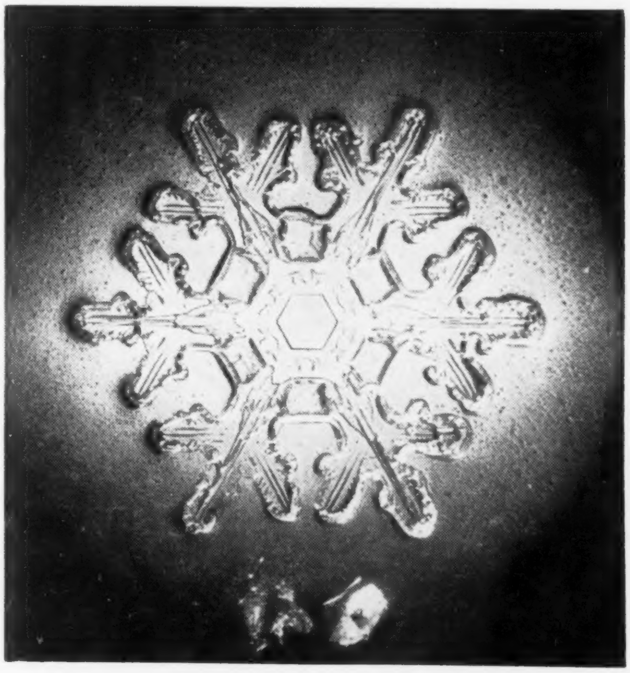


FIG. 1 A SNOW CRYSTAL, REPRODUCED AND MADE PERMANENT BY MR. SCHAEFER'S METHOD

REVIEWS OF BOOKS

And Notes on Books Received in the Engineering Societies Library

Surface Finish

Surface Finish. By George Schlesinger. Institution of Production Engineers, London, England, 1942. Cloth, $5^1/_2 \times 8^3/_4$ in., 231 pp., illus., 15s 6d.

Reviewed by Stewart Way[1]

EVER since the appearance of the preliminary report of the Institution of Production Engineers on Surface Finish, in *Engineering*, March 29, 1940, a great many production men and research workers in this country have been looking forward to publication of the complete report. This report is now available in the form of a compact treatise by Dr. George Schlesinger, who is director of the research department of the Institution.

Dr. Schlesinger's book is particularly welcome because it is one of the few books in the English language on the timely subject of surface finish and because it brings together much new and hitherto unpublished information. In the six years that have elapsed since the publication of Schmaltz' book[2] much progress has been made in producing and measuring metal surface finishes. No small part of this progress has come about through the work of Dr. Schlesinger and his co-workers.

The study was undertaken to provide standards for the measurement and rating of metal surfaces and to summarize standard practice in Great Britain as regards the type of finish which is applied to various machine parts by reputable manufacturers.

In the course of the work four hundred thirty-six finished surfaces on machine parts were examined by several different methods of evaluating finish; the tabulation of the results of these measurements in the last forty-eight pages of the book is one of its most valuable features. The parts examined included 82 specimens from automobiles, 100 items from lorries and busses, 47 from aircraft engines, 3 railway parts, 47 machine-tool parts, 22 electrical-equipment items, 10 instrument parts, 16 gears, 11 roller-bearing parts, 3 fuel-injector parts, 86 elements of gages and measuring devices, and 10 comparison standards.

The data given on these finish specimens, which were loaned by British manufacturers, include:

Specimen number
Description of part
Material
Function and fit
Machining operations
Sketch
Class of finish, by recommended standard
h_{ave}, average departure from mean surface
h_{rms}, by profilometer
h_{max}, by oscillograph-pen record
h_{max}, by Schmaltz' optical cut
h_1, average height of peaks
h_2, average depth of hollows
F_1, form factor, h_1/h_{max}
F_2, form factor, h_2/h_{max}

All distances are given in microinches. The tabulation thus affords not only a valuable compilation of finishes produced by various operations but also a revealing comparison between the results of measurement with various instruments.

Quality-control men and designers will be interested in the proposed British standard on surface roughness, for it is similar in many respects to our American Standard (Committee B46). A tabulation of the finish classes is here reproduced:

Step number	American Standard (Range in microinch) h_{rms}	British Standard (Range in microinches) h_{ave}
1	$<1/4$	1.1–2
2	$1/4$–$1/2$	2.1–4
3	$1/2$–1	4.1–8
4	1–2	8.1–16
5	2–4	16.1–32
6	4–8	32.1–63
7	8–16	63.1–125
8	16–32	126 –250
9	32–63	251 –500
10	63–250	501 –1000
11	250–1000	1001 –2000
12	1000–4000	2001 –4000
13	4000–16000	
14	16000–63000	

In the British recommendation the class number of the finish is identical with the step number in this table; in addition, a class 0 is used for finishes with h_{ave} less than 1 microinch. In the American standard a finish is specified, not by the step number, but by the upper limit of the h_{rms} range; thus a finish designated as 32 microinch rms in the American standard would be one of range 16 to 32 microinches. It would correspond approximately to a finish of class 5 in the British nomenclature. The V symbol with finish number placed above is proposed in the British standard, as in the American. In addition, however, the British proposed standard prefixes the V by a letter designating the machining operation. Thus, finish G$\overset{5}{\text{V}}$ represents a ground finish of class 5.

The proposed British standard utilizes the quantity h_{ave} rather than h_{rms}. This is the average deviation of the surface from the mean line, rather than the root-mean-square deviation. The argument used in favor of h_{ave} is its supposed easier acceptance and comprehension by shop personnel. Meter indication of the h_{ave} value (obtained by electrical means) is held to be not more difficult than meter indication of h_{rms}.

Several measuring instruments that may be new to American engineers are described. The principal one is the Taylor-Hobson surface meter. It combines some features of the Abbott profilometer and the Brush surface analyzer and introduces some new features of its own. Using a diamond stylus of 0.0001 in. tip radius and electromagnetic-type pickup, the pickup voltage is fed to an a-c amplifier and from there to either a meter calibrated in microinches h_{ave} or to a pen-recording oscillograph. The stylus pressure is 0.1 gm to 0.2 gm as contrasted with 0.02 to 0.05 gm on the Brush instrument point. The speed of traverse is 0.0075 in. per min as contrasted with 0.72 in. per min with the Brush pickup arm. The apparent reason for the slow traverse is that the Taylor-Hobson recorder arm responds faithfully only up to 2 cycles per second, whereas the Brush oscillograph operates faithfully up to 60 cycles per second. The speed of traverse of the Taylor-Hobson pickup is so low, however, that irregularities of wave length as small as 0.0001 in. may be measured, whereas with the Brush instru-

[1] Research Laboratories, Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa. Jun. A.S.M.E.

[2] "Technische Oberflächenkunde," by G. Schmaltz, J. Springer, Berlin, 1936.

ment the lower limit for faithful reproduction is at a wave length of about 0.0002 in. There are two speeds of traverse on the Taylor-Hobson instrument, being 0.0075 in. per min and 0.030 in. per min, furnishing horizontal chart magnifications of 600 and 150×, respectively. Vertical magnifications up to 40,000× may be obtained. The meter reading of h_{ave} is an average value from the start of the traverse, not an instantaneous average value. The nature of the electrical circuits in the Taylor-Hobson instrument is apparently such that a constant stylus displacement produces a constant meter indication or a constant pen deflection, a very desirable feature. Apparently the pickup motion causes amplitude modulation of a supplied alternating current, rather than generation of a current. The Taylor-Hobson surface meter is less portable than either of the two commonly used American instruments.

Another new instrument described is the Tomlinson surface-finish recorder. This is also a tracer-type instrument which sacrifices range and accuracy in the interest of simplicity of construction and compactness. The scriber is directly connected by an ingenious mechanical linkage to the stylus mounting. A magnification of 160× is obtained from stylus to scriber, and additional magnification is obtained by enlargement of the scribed record. To obtain a fine line, a pointed scriber is used on a smoked rotating glass disk. The book describes also a number of surface comparators.

One of the most interesting sections of the book deals with the tolerances and finishes on plug and snap gages and on gage blocks. The finish measurements on these tools are quite enlightening. A full chapter is devoted to the question of the scratching effect of the tracer point and the ability of the tracer point to reach the bottom of variously formed scratches. [Inquiries concerning the purchase of this book should be addressed to the A.S.M.E. Publications Sales Department, 29 West 39th St., New York, N. Y.—EDITOR.]

Library Services

ENGINEERING Societies Library books may be borrowed by mail by A.S.M.E. members for a small handling charge. The Library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Harrison W. Craver, Director, Engineering Societies Library, 29 West 39th St., New York, N. Y.

Air Conditioning

MODERN AIR CONDITIONING, HEATING AND VENTILATING. By Willis H. Carrier, Realto E. Cherne, and Walter A. Grant. Pitman Publishing Corporation, New York, N. Y., 1940. Cloth, 6 × 9 in., 547 pp., illus., $4.50.

REVIEWED BY ARTHUR M. GREENE, JR.[3]

THIS book by three of the engineers of one of the companies having much to do with the modern development of air conditioning and ventilating is a great contribution to the literature of the subject and an important aid for those who are attempting to practice design. From the experiences and the methods of the Carrier Corporation and from the Transactions of the American Society of Heating and Ventilating Engineers they have assembled data and procedures and presented them in a logical order for use in an authoritative manner. This manner comes from years of successful experience and gives the user of the text confidence in his work and assurance of its adequacy.

After discussing psychrometrics and comfort with the estimating of requirements in chapters 2 and 3, the fourth chapter on economics points out that selections must not only be made to fulfill physical requirements but financial elements enter all problems.

The chapters on heat-producing equipment and on heat-distributing equipment are followed by those on steam-heating systems and on hot-water systems, with one on automatic controls and zoning for heating.

Chapter 10 on fans, heaters, and ventilators contains many important suggestions which have resulted from the long years of experience with the use of this equipment by the authors. It contains many sample calculations relating to air and compares unit heaters with central-plant ventilating systems. This naturally leads to chapter 11 on air-cleaning devices and humidifiers and the next one on the design of the air-duct systems. In the second paragraph of this latter chapter the statement "for this reason in large installations, worthwhile economies can be realized by designing the ducts to balance first cost against operating costs rather than using rule-of-thumb methods sometimes permissible on smaller installations" indicates the type of valuable suggestions throughout the book resulting from experience which required economic considerations to justify expenditures of money.

Chapter 13 on cooling and dehumidification with the numerical examples gives the basic calculations of requirements and size of equipment for air conditioning. The next chapter describes the equipment and chapter 15 discusses refrigeration for air conditioning. The subjects of air distribution, zoning controls, and noise and vibration are treated before the chapter which deals with the application of this subject to various types of structures.

The final chapter covers the subject of residential heating and air-conditioning systems in which examples of computations and description of equipment are given.

An appendix contains tables and charts which are for use in the solution of problems and the making of designs for the apparatus needed for a given structure, without reference to other texts.

[3] Dean Emeritus, School of Engineering, Princeton University, Princeton, N. J. Past Vice-President and Hon. Mem. A.S.M.E.

AIR CONDITIONING PRINCIPLES. By Charles O. Mackey. International Textbook Company, Scranton, Pa., 1940. Fabrikoid, 6 × 9 in., 210 pp., illus., $2.

REVIEWED BY ARTHUR M. GREENE, JR.[3]

THIS text is devoted principally to the theory underlying air conditioning and to problems dealing with the conditioning of air for the maintenance of desired characteristics of the air within a definite space. As stated in the preface, there is little if any descriptive matter. The book is therefore primarily for the practicing engineers or the graduate students who are familiar with apparatus used in air conditioning.

The properties of air and mixtures of air and water vapor are covered in chapter 1 and reference is made to the works of August, Maxwell, Arnold, and Prandtl on the subject of the wet-bulb thermometer but no references are made to the papers written by these investigators so that the student or the user of the book may use the original complete sources. Formulas are quoted on this subject with no statement of the full significance of them. In this chapter a number of numerical reductions indicate poor proofreading or a lack of the cross checking of computations.

The use of enthalpy and the "sigma" function of Carrier are given in the second chapter for mixtures of air and water vapor. At the end of this chapter, as

well as at the end of each chapter, there is an excellent set of problems for solution in which the principles of the chapter are to be used. Answers are given at the end of the book.

Physical and physiological principles of chapter 3 are used to determine the human requirements of the spaces to be conditioned, giving data for the determination of these. The use of effective temperature, which is a temperature, is introduced in this chapter.

Equations of balanced energy and balanced weight for the determination of the necessary air supply with the given sources of heat and moisture are explained in chapter 4, while in chapter 5 the humidification of air is examined with the use of the contact mixture theory of Carrier. No mention is made of the place of publication of this. This theory is not clearly presented and the purpose or use of the Prandtl analogy as given on page 54 is not made evident.

The heating and humidification of the air for winter conditions are treated in chapter 6 with the necessary data for heat and water-vapor losses from buildings being given in chapter 7. Dehumidification and cooling of air for summer conditions are treated in chapter 8 based on the data in chapter 10 on heat and water-vapor gains.

The last chapter, on the transmission and distribution of air, discusses the losses of pressure in pipes or ducts, the common velocities used in different parts of the system, the steps in the design of ducts, the discharge and throw from outlets, fan requirements, and characteristics and the selection of outlets.

The sample problems worked out in the text with the problems for solution make this text of particular value to the engineer who is entering this field of work for the first time.

Books Received in Library

AIRCRAFT APPRENTICE. By L. MacGregor. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1942. Cloth, $5^1/_2 \times 8^1/_2$ in., 134 pp., illus., diagrams, charts, tables, $1.50. This book has been written to give the boy of high-school age a better understanding of the workers in the aircraft industry and their jobs. The requirements, opportunities, and resources for proper training in this industry are set forth, flight and engine principles are explained in a simple manner, and the machines and processes used in the manufacture of aircraft are briefly described.

AIRCRAFT ASSEMBLY. By C. F. Marschner. Pitman Publishing Corporation, New York, N. Y., and Chicago, Ill., 1942. Cloth, $5^1/_2 \times 8^1/_2$ in., 104 pp., illus., diagrams, tables. Aircraft assembly procedure, design, and equipment are briefly covered in the first three chapters. Succeeding chapters deal with the specific operations necessary for attaching and grouping together the many parts which make up the various basic structural units. The last chapter covers the final assembly of the complete airplane.

AIRCRAFT HANDBOOK. By F. H. Colvin. Fifth edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Leather, $5^1/_2 \times 8^1/_2$ in., 784 pp., illus., diagrams, charts, tables, $5. The new edition of this handbook presents detailed and considerably expanded information about all types of airplane engines, propellers, instruments, and other equipment. In order to provide such a manual, of particular assistance to the ground mechanic, previously included material on flight theory, airplane design and construction, etc. has been omitted. Inspection and maintenance work have been emphasized.

AIRCRAFT LAYOUT AND DETAIL DESIGN. By N. H. Anderson, with a foreword by C. T. Reid. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1941. Cloth, $6 \times 9^1/_2$ in., 306 pp., illus., diagrams, charts, tables, $3. The three main objects covered in this text are descriptive geometry, detail design, and fitting analysis. Only those portions of descriptive geometry that have common application to aircraft structures are considered. In detail design, fundamentals are emphasized rather than specific shop methods, although the guiding principles are so laid out that any part should be practicable to produce. Sufficient stress analysis is presented for an intelligent determination of minimum weight for required strength.

AIRCRAFT SHEET METALWORK, Part 1: The Textbook. Cloth, 7×10 in., 123 pp., $2.50. Part 2: Workbook in Blueprint Form. Paper, $8^1/_2 \times 13^1/_2$ in., 58 pp., $1.50. By J. W. Giachino. Manual Arts Press, Peoria, Ill., 1942. Illus., diagrams, charts, blueprints, tables. Part 1 of this two-volume set describes the layout, cutting, bending, forming, riveting, and development operations performed in aircraft sheet-metal work. Part 2, the workbook, presents in blueprint form actual jobs for the practical application of the information given in volume one. The text also contains a brief chapter dealing with aluminum and its alloys.

AIR PILOT TRAINING. By B. A. Shields. McGraw-Hill Book Co., Inc. (Whittlesey House), New York, N. Y., and London, England, 1942. Cloth, $6 \times 9^1/_2$ in., 602 pp., illus., diagrams, charts, maps, tables, $4. The four sections of this book cover the essential material required for private and commercial pilots' licenses. They deal respectively with aircraft and the theory of flight, aircraft engines, meteorology, and air navigation. Elementary principles are fully explained and are tied in with their applications to appropriate types of flight problems or procedures. Previous technical education is not required.

AIRPLANE AND ITS COMPONENTS. (Galcit Aeronautical Series.) By W. R. Sears. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1942. Cloth, $6 \times 9^1/_2$ in., 75 pp., illus., diagrams, charts, tables, $1.25. A condensed general survey of the field of airplane design is presented as an introduction for students and workers with some technical knowledge. Airplane types, their external and internal components, aircraft radio and instruments, engines, and propellers are briefly discussed, with emphasis on basic engineering principles. Characteristic problems are pointed out and typical solutions indicated.

AIRPLANE METAL WORK, Volume 4. Airplane Pneumatic Riveting, 103 pp.; Volume 5. Airplane Sheet Metal Repair, 94 pp. By A. M. Robson. D. Van Nostrand Co., Inc., New York, N. Y., 1942. Paper, $7 \times 9^1/_2$ in., illus., blueprints, diagrams, tables, $1.25 each. These volumes continue a series intended for mechanics actively engaged in the aircraft industry and for prospective mechanics in training. Volume 4 contains, first a general discussion of work habits and operations related to riveting, and then descriptions of actual jobs occurring in pneumatic-riveting shop practice. Volume 5 presents a section of related trade information for sheet-metal repair and, as before, follows with detailed descriptions of actual jobs in the sheet-metal repair shop. There are also in each volume full lists of necessary tools and miscellaneous equipment and tables of useful data.

AIRWAYS, the History of Commercial Aviation in the United States. By H. L. Smith. Alfred A. Knopf, New York, N. Y., 1942. Cloth, 6×9 in., 430 pp., illus., charts, maps, tables, $3.50. The object of this book is to present a broad picture of commercial aviation. The author describes the early period and the slow development, other than military, up to 1925. In the following important decade commercial air lines went through the phases of pioneering, merger, regulation, and stabilization, and this period and succeeding years are covered in considerable detail. Bibliographical notes, a condensed chronology, and other important data are contained in an appendix.

BENCH WORK UNIT. Dunwoody Series, Machine Shop Training Jobs. 155 pp., $1.35; (work sheets, $0.30). GRINDER JOB TRAINING UNITS. Dunwoody Series, Machine Shop Training Jobs. 111 pp., $1.25; (work sheets, $0.30). American Technical Society, Chicago, Ill., 1942. Paper, $8^1/_2 \times 11$ in., illus., diagrams, charts, tables. These publications belong to a series of six manuals for training on various machine tools. General and special procedures in working with the respective machines are briefly described with the care and use of necessary tools. Detailed instructions are given for a series of practical jobs, including check sheets for determining the learner's grasp of each problem, and a final section relates the knowledge gained to actual shop work. Helpful hints are also given on blueprint reading.

BLUEPRINT READING, a Visualized Method of Instruction. By A. A. Dick. Ronald Press Co., Inc., New York, N. Y., 1942. Cloth, $6^1/_2 \times 10^1/_2$ in., 157 pp., diagrams, tables, blueprints, $2.40. The purpose of this book is to give the student an understanding of the fundamental principles underlying mechanical drawing as well as to teach him to interpret blueprints. Part 1 presents basic methods of representation of objects by drawings. Part 2 contains assignments, consisting of sample blueprints with accompanying questions and problems, which increase in difficulty as the student proceeds.

CHEMICAL ENGINEERING FOR PRODUCTION SUPERVISION. (Chemical Engineering Series.) By D. E. Pierce. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, $6 \times 9^1/_2$ in., 232 pp., diagrams, charts, tables, $2.50. A simple

explanation is given of the fundamental chemical-engineering principles upon which the successful operation of plant equipment depends. The book presents those basic principles of chemistry, physics, and thermodynamics most useful to the operating man, together with their application to five unit operations: Heat transfer, evaporation, distillation, drying, and flow of fluids.

CHEMICAL ENGINEERING PLANT DESIGN. (Chemical Engineering Series.) By F. C. Vilbrandt. Second edition. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9$^1/_2$ in., 452 pp., diagrams, charts, tables, maps, $5. This volume analyzes the fundamental principles and factors that are involved in the development of a technically and economically efficient plant process from the laboratory stage through the pilot plant stages to the unit of commercial size. The author discusses such topics as foundations, drainage, piping, pumps, flow diagrams, equipment selection, plant layout, and power. The last two chapters deal with preconstruction cost accounting and plant location.

THE CONDENSED CHEMICAL DICTIONARY, compiled and edited by the editorial staff of the Chemical Engineering Catalog. Third edition. T. C. Gregory, editor. Reinhold Publishing Corporation, New York, N. Y., 1942. Cloth, 6 × 9 in., 756 pp., tables, $12. This useful reference work is intended for manufacturers, purchasing agents, and others who need concise, accurate information about chemicals. Over eighteen thousand terms are listed, with synonyms, composition, properties, uses, shipping regulations, etc. Many trade and proprietary names are included, and a collection of useful tables is appended.

COTTON LOOMFIXERS' MANUAL. By I. Moberg. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9 in., 197 pp., illus., diagrams, charts, tables, $2.50. Practical, step-by-step instructions are given on all phases of cotton loom fixing. The book covers the setting, adjusting, and timing of modern looms and the latest loom motions as applied on older looms. The material is so presented that the book can serve as a textbook for courses or as a self-study manual.

DAVISON'S RAYON AND SILK TRADES, Including Nylon and Other Synthetic Textiles. The Standard Guide, 47th annual pocket edition. Davison Publishing Co., Inc. Ridgewood, N. J., 1942. Cloth, 5 × 7$^1/_2$ in., 412 pp., maps, tables, $5.50. This directory of mills, dyers, finishers, and dealers in the rayon and silk trades contains both geographical and classified lists, as well as an alphabetical index. A buyers' guide indicates sources for equipment, and the railroads serving the various plants are listed.

DIAMOND AND GEM STONE INDUSTRIAL PRODUCTION. By P. Grodzinski. N.A.G. Press Ltd., London, England, 1942. Cloth, 5$^1/_2$×8$^1/_2$ in., 256 pp., diagrams, charts, tables, 15s. This work deals with the selection, cutting, polishing, and drilling of diamonds and gem stones for industrial purposes. The first part covers general methods; the second part discusses special methods for the manufacture of ornamental gems, jewel bearings, and diamond dies for setting industrial diamonds and for grinding and lapping sintered carbides. A descriptive list of technically used hard materials is appended with other useful data.

ELASTIC ENERGY THEORY. By J. A. Van den Broek. Second edition. John Wiley & Sons, Inc., New York, N. Y., Chapman & Hall, London, England, 1942. Cloth, 6 × 9$^1/_2$ in., 298 pp., diagrams, charts, tables, $4.50. The theory of elastic energy as an instrument for the solution of problems involving statically indeterminate structures is presented as a text for an elementary course in strength of materials. The graphical summation method is used, because of its more general character and ease of application. The book is designed to be of use to practical engineers as well as to college students.

ENGINEERING ECONOMIC ANALYSIS. By C. E. Bullinger. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9$^1/_2$ in., 359 pp., diagrams, charts, tables, $3.50. The chief aim of this text on cost analysis as applied to engineering projects is to give students an understanding of the economic factors which are present in the engineering process. The four main parts of the book deal respectively with: The economy analysis, probable yield on the investment; the intangible analysis, consideration of human relationships; the financial analysis, provision of funds; and special methods and applications.

GAGES AND THEIR USE IN INSPECTION. By F. H. Colvin. McGraw-Hill Book Co., Inc., New York, N. Y., and London, 1942. Cloth, 5 × 7$^1/_2$ in., 157 pp., illus., diagrams, charts, tables, $1.50. A complete introduction to the use of gages, this book is especially valuable for those who wish to become inspectors. It points out why gages are made, describes all types, and shows plainly how they are used in a variety of work. Tolerances, limits, and allowances are covered, with discussion of the proper use of these terms.

HEATING, VENTILATING, AIR CONDITIONING GUIDE 1942, Vol. 20. American Society of Heating and Ventilating Engineers, New York, N. Y., 1942. Cloth, 6 × 9$^1/_2$ in., 1160 pp., illus., diagrams, charts, tables, $5. The new edition of this valuable reference work follows the pattern of preceding ones Section 1 presents the essential technical data for heating, ventilating, and air conditioning. This section has been thoroughly revised and largely rewritten to include recent information. Section 2 contains catalogue data by many manufacturers of equipment. Section 3 is the membership list of the Society.

HISTORY OF COMBAT AIRPLANES. The James Jackson Cabot Professorship of Air Traffic Regulation and Air Transportation at Norwich University, Publication No. 7. By C. G. Grey. Norwich University, Northfield, Vt., December, 1941. Paper, 6 × 9 in., 158 pp., $1. The author describes in considerable detail examples of the many types and variations of airplanes which were developed specifically for combat from 1914 to the present day. All countries are covered, comparisons are indicated, and the men who played the leading parts in this development are given due credit.

HYDRAULICS. By G. E. Russell. Fifth edition. Henry Holt & Co., Inc., New York, N. Y., 1942. Cloth, 6 × 9$^1/_2$ in., 468 pp. illus., diagrams, charts, tables, $4.25. The fundamental principles of hydraulics are presented in a clear, logical manner for students and for use as a reference book by engineers. Although the text is devoted mainly to hydraulics, the flow of other liquids and of compressible fluids is briefly discussed. The basic text material has been completely revised for the first time since 1925, and the chapters on hydraulic turbines and centrifugal pumps, added in the previous edition, have been brought up to date.

INDUSTRIAL ACCOUNTING. By S. W. Specthrie. Prentice-Hall, Inc., New York, N. Y., 1942. Cloth, 6 × 9$^1/_2$ in., 243 pp., charts, tables, $3.75. This volume is intended as a text for engineers, engineering students, and industrial administrators who wish to gain an understanding of the processes and executive uses of industrial accounting. The early chapters present basic accounting principles and bookkeeping procedures. This is followed by a course in the theory and practice of cost accounting. Finally, the executive use of accounting data is discussed.

INDUSTRIAL SUPERVISION, CONTROLS. 267 pp. INDUSTRIAL SUPERVISION, ORGANIZATION. 283 pp. (The Pennsylvania State College, Industrial Series.) By V. G. Schaefer, W. Wissler, and others. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1941. Cloth, 5 × 8 in., diagrams, charts, tables, $1.75 each. These two volumes deal with the problems of the foreman in industry. The one on controls discusses the various methods of control by which morale and safety are promoted and waste and turnover are lessened. The volume on organization considers what can be done with the worker and in co-ordinating workers with jobs in order to increase efficiency in production.

INDUSTRIAL WASTE TREATMENT PRACTICE. By E. F. Eldridge. McGraw-Hill Book Co., Inc., New York, N. Y., and London, England, 1942. Cloth, 6 × 9$^1/_2$ in., 401 pp., illus., diagrams, charts, tables, $5. Until now, the available information on the treatment of industrial waste has been widely scattered and badly in need of organization. The present work endeavors to do this, on the basis of the author's experience and the literature. The general principles of waste treatment methods and equipment are first discussed, after which specific industries are considered, such as beet sugar, milk products, canning, tanning, pulp and paper making, meat packing, oil refining, etc. Prominence is given to the design of structures for full-scale treatment.

MANUAL OF ELEMENTARY MACHINE SHOP PRACTICE. By E. C. Phillips. Burgess Publishing Co., 426 South Sixth St., Minneapolis, Minn., 1941. Paper, loose-leaf spiral binder, 8$^1/_2$ × 11 in., 199 pp., illus., diagrams, tables, $2.50. The content of this manual has been written for the use of those making their first acquaintance with the machines, tools, and processes commonly employed in machine-shop work. The material consists of operation sheets which give step-by-step procedures for shop operations, and information sheets which simply describe tools and processes, and the necessary computations.

MODERN GUN PRODUCTION. Compiled by and reprinted from *Steel*. Penton Publishing Co., Cleveland, Ohio, 1941. Paper, 9 × 11$^1/_2$ in., 51 pp., illus., diagrams, $1. This pamphlet brings together in convenient form a number of articles which have previously appeared in *Steel*. The principles of gun construction and manufacturing operations as carried out at the Watervliet Arsenal and by the Struthers-Wells-Titusville Corporation are described. There are also articles on the design and production of gun carriages, recoil mechanism, range finders, and fire-control instruments.

MODERN MARINE ENGINEER'S MANUAL, Vol. 1. Edited by A. Osbourne and others. Cornell Maritime Press, New York, N. Y., 1941. Cloth, 5 × 7$^1/_2$ in., 1696 pp., illus., diagrams, charts, tables, $6. This manual has been written to provide a comprehensive American textbook that will adequately ex-

plain the design and operation of all the general types of marine equipment. This first of two volumes covers such fundamentals as mathematics, engineering materials, thermodynamics and combustion, and such equipment as boilers, reciprocating engines, and steam turbines, together with certain auxiliaries. Each chapter is the product of a specialist, and simplicity is the keynote.

MODERN MARINE PIPE FITTING. By E. M. Hansen. Cornell Maritime Press, New York, N. Y., 1941. Cloth, 5 × 7½ in., 434 pp., illus., diagrams, charts, tables, $3. The essentials of marine pipe fitting, with particular regard for special conditions, are presented in this textbook for students and apprentices. Emphasis has been laid on what the pipe fitter will have to know in each phase of his work, as he follows a job from blueprint to completed installation on board ship. Glossaries of shipbuilding and pipe-fitting terms are included, and there are many working drawings and photographs.

MODERN SHELL PRODUCTION. Compiled by and reprinted from *Steel*. Penton Publishing Co., Cleveland, Ohio, 1941. Paper, 9 × 11½ in., 159 pp., illus., diagrams, charts, tables, $1.50. The material contained in the first and second handbooks on ordnance production prepared by *Steel* appears again in the present publication, together with new material on the manufacture of cartridge cases, ammunition for small arms, and bombs and fuses.

NOMENCLATURA DE TERMINOS AERONAUTICOS. By D. H. Nelson, translated by E. Borda. Editorial Tecnica Unida, Chemical Publishing Co., Brooklyn, N. Y., 1941. Cloth, 5 × 7½ in., 69 pp., diagrams, $2. This is a Spanish translation of the author's "Glossary of Aeronautical Terms," to which has been added a list of English terms with Spanish equivalents.

Notes and Problems in BLUE PRINT READING OF MACHINE DRAWINGS. By D. E. Hobart. Harper & Brothers, New York, N. Y., and London, England, 1941. Paper, 8½ × 11 in., 105 pp., diagrams, $1. The material presented in this book is the outgrowth of the author's experience in teaching the reading of machine drawings to men taking courses in machine-shop practice. The basic principles for reading both detail and assembly drawings are explained, and a large group of sample problem sheets is appended.

OIL WELL DRAINAGE. By S. C. Herold. Stanford University Press, Stanford University, Calif., 1941. Cloth, 7 × 10½ in., 407 pp., illus., diagrams, charts, maps, tables, $5. Events and conditions within a producing reservoir are described, and the influence of well performance on the movement of the oil and gas is presented in simple terms. Analogies between artificial and natural reservoirs are considered, the nature of reservoir energy is discussed, and the function of gas in the production of oil is set forth. The chapters are divided into two parts, for two types of wells with distinct features in drainage. Many citations of field examples are included.

PETROLEUM REFINERY ENGINEERING. By W. L. Nelson. Second edition. McGraw-Hill Book Co., New York, N. Y., and London, England, 1941. Cloth, 6 × 9½ in., 715 pp., illus., diagrams, charts, tables, $6. The fundamentals of engineering design and processing in the field of refining are presented in this comprehensive text. The composition and properties of petroleum oils, the principles which govern their treatment, and the equipment used for the various processes are dealt with at length. The revised edition contains new chapters on rebuilding hydrocarbons, auxiliaries to processing, and solvent treating or extraction processes. New references have been added to many of the chapters.

PLANT PRODUCTION CONTROL. By C. A. Koepke. John Wiley & Sons, Inc., New York, N. Y.; Chapman & Hall, London, England, 1941. Cloth, 6 × 9 in., 509 pp., illus., diagrams, charts, tables, $4. The maximum production of goods with minimum confusion and expense is the concept dealt with in this book. To this end production control is broken down into its several functions. Each function is treated separately, yet co-ordinated with the others to show how control of production is obtained for various situations. Review questions and a short bibliography accompany each chapter.

PRACTICAL MARINE DIESEL ENGINEERING. By L. R. Ford. Third edition, Simmons-Boardman Publishing Corp., New York, N. Y., 1941. Cloth, 6 × 9½ in., 590 pp., illus., diagrams, charts, tables, $5. Construction, operation, and maintenance of marine Diesel engines are explained from the viewpoint of the operating engineer. Latest developments in new types of equipment associated with motor-ship propulsions, such as couplings, superchargers, etc., are discussed, and there are chapters on methods and requirements for obtaining a motor-ship license. This third edition is limited to American engines.

PRACTICAL PRINCIPLES OF NAVAL ARCHITECTURE. By S. S. Rabl. Cornell Maritime Press, New York, N. Y., 1941. Cloth, 5 × 7½ in., 181 pp., diagrams, charts, tables, $2. This simple introductory volume for the student and practical worker explains first the essential mathematics. It then describes the various steps leading to the construction of the ship: lines, buoyancy, displacement, stability and trim calculations, etc. Launching is discussed, and the later chapters deal with the strength of materials and floating structures.

PRINCIPLES OF PHYSICAL METALLURGY. By G. E. Doan and E. M. Mahla. Second edition. McGraw-Hill Book Co., New York, N. Y., and London, England, 1941. Cloth, 6 × 9½ in., 388 pp., illus., diagrams, charts, tables, $3.50. This textbook aims to supply a unified account of present-day knowledge of metals and alloys, with special reference to their behavior when operated upon in manufacturing. The physics of metals, metallography, and metal technology are successively discussed, attention being focused upon the principles of the behavior of metals as a whole, not of individual metals or alloys.

RUNNING A MILLING MACHINE. By F. H. Colvin. McGraw-Hill Book Co., New York, N. Y., and London, England, 1941. Cloth, 5 × 8 in., 157 pp., illus., diagrams, charts, tables, $1.50. This simple, well-illustrated introductory book gives a working knowledge of milling machines and shows how they are used. It covers the different kinds of machines, their parts, the kind of work each does, how to operate each kind, proper speeds and feeds, etc.

SURFACE TREATMENT OF METALS, Symposium held during the 22nd Annual Convention of the American Society for Metals, Cleveland, Ohio, October 21 to 25, 1940. American Society for Metals, Cleveland, Ohio, 1941. Cloth 6 × 9½ in., 427 pp., illus., diagrams, charts, tables, $5. Fifteen papers by authorities are presented in this symposium on the treatment of metal surfaces. The wide range is indicated by the following sample topics: anodic treatment of aluminum; corrosion resistance of tin plate; diffusion coatings on metals; induction heat-treating; shot-blasting; effect of surface conditions on fatigue properties; etc.

TABLE OF NATURAL LOGARITHMS, Vol. 3. Logarithms of the Decimal Numbers from 0.0001 to 5.0000, prepared by the Federal Works Agency, Work Projects Administration for the City of New York, conducted under the sponsorship and for sale by the National Bureau of Standards, Washington, D. C., 1941. Cloth 8 × 11 in., 501 pp., tables, $2, payment in advance. This present volume, the third in a series of four, contains the values to sixteen decimal places of the natural logarithms of the decimal numbers from 0 to 5 at intervals of 0.0001. Methods for interpolation and inverse interpolation are given.

TEXT BOOK OF ADVANCED MACHINE WORK. By R. H. Smith. Twelfth edition, revised and enlarged; paged in sections. Industrial Education Book Co., Boston, Mass., 1940. Cloth, 5 × 8 in., diagrams, tables, $3.25. A companion volume to the author's "Principles of Machine Work," this book covers a wide range of machine-shop operations. In addition to full descriptions of the tools and processes, schedules of the various operations are given, which provide a complete plan in tabular form of many typical problems in machine construction. These schedules, together with the large number of illustrations, increase the practicality of the book for the inexperienced worker.

Textbook of the MATERIALS OF ENGINEERING. By H. F. Moore, with a chapter on Concrete by H. F. Gonnerman, and a chapter on The Crystalline Structure of Metals by J. O. Draffin. Sixth edition. McGraw-Hill Book Co., New York, N. Y., and London, England, 1941. Cloth, 6 × 9½ in., 454 pp., illus., diagrams, charts, tables, maps, $4. The physical properties of the common materials used in structures and machines, together with descriptions of their manufacture and fabrication, are presented concisely in suitable form for use as a college textbook. The new edition has an added chapter on plastics, and extensive changes and additions have been made throughout the book.

THEORETICAL AND PRACTICAL ELECTRICAL ENGINEERING, 2 Vols. By L. D. Bliss. Fifth edition. Bliss Electrical School, Washington, D. C., 1941. Vol. 1, 631 pp.; Vol. 2, 671 pp. Cloth, 6 × 9½ in., illus., diagrams, charts, tables, $8 for both volumes. These two volumes contain a course of lectures given at the Bliss Electrical School on the principles and applications of both direct- and alternating-current apparatus. The early chapters discuss fundamental electrical theories, laws and types of instruments. Generators, motors, and transformers are treated in detail; and consideration is given in later chapters to telegraphy, telephony, electronic devices, illumination, electric railways, and other applications of electricity.

THERMODYNAMICS. By J. H. Keenan. John Wiley & Sons, Inc., New York, N. Y., 1941. Cloth, 6 × 9 in., 499 pp., diagrams, charts, tables, $4.50. The object of this book is to give a simple and rigorous exposition of the first and second laws of thermodynamics. Work, temperature, and heat are explicitly defined. The concept of reversibility, entropy, the availability principle, the relations between pressure, volume, and temperature, and states of equilibrium are some of the important subjects discussed. Consideration is also given to engines, cycles, refrigeration, air conditioning, and other thermodynamic applications.

A.S.M.E. NEWS

And Notes on Other Engineering Activities

Aids to War Production Discussed at 1942 Semi-Annual Meeting of A.S.M.E., Cleveland, June 8–10

Extensive Technical Program Enjoyed by 800 Members

THE intense interest of mechanical engineers in war production and all vital services related to the war effort brought more than 800 members and guests together at the Hotel Statler, Cleveland, Ohio, June 8–10, for the 1942 Semi-Annual Meeting of The American Society of Mechanical Engineers.

The technical program of the meeting was announced in the June issue of the A.S.M.E. News and covered a wide variety of subjects in which the professional divisions of the Society are interested. Two divisions, Oil and Gas Power and Applied Mechanics, had arranged national meetings elsewhere, the former at Peoria, Ill., June 17–19, and the latter at Cambridge, Mass., June 19–20, and hence were not represented on the Cleveland program.

In accordance with custom and the rules of the Society there were also held at Cleveland meetings of the Council and its Executive Committee and the semi-annual business meeting of the Society. Throughout the three days of the meeting the Nominating Committee was in session, and on Wednesday afternoon the nominations for officers of the Society to serve for the administrative year, commencing with the close of the 1942 Annual Meeting next December were announced.

H. V. Coes Nominated for President

The officers named by the Nominating Committee to be voted on by the members of the Society in the fall were as follows:

For president, Harold V. Coes, vice-president, Ford, Bacon and Davis, New York, N. Y.

For vice-presidents: Joseph W. Eshelman, manager 1939–1942, president, Eshelman and Potter, Birmingham, Ala.; Guy T. Shoemaker, manager 1939–1942, vice-president, Kansas City Light and Power Company, Kansas City, Mo.; Walter J. Wohlenberg, professor of mechanical engineering, School of Engineering, Yale University, New Haven, Conn.; and Thomas E. Purcell, general superintendent of power stations, Duquesne Light Company, Pittsburgh, Pa. (to fill the unexpired term of W. H. Winterrowd, deceased).

For managers: Roscoe W. Morton, professor of mechanical engineering, University of Tennessee, Knoxville, Tenn.; A. E. White, director, department of engineering research, University of Michigan, Ann Arbor, Mich.; and A. R. Stevenson, Jr., staff assistant to vice-president in charge of engineering, General Electric Company, Schenectady, N. Y.

Biographical sketches of these nominees for office will appear in the August issue of MECHANICAL ENGINEERING.

20 Technical Sessions

The technical program at Cleveland finally shaped itself into 20 sessions, of which four were round-table discussions, and at which 44 papers were presented. Represented on the program as sponsoring sessions were the following divisions: Aviation, Metals Engineering, Production Engineering, Wood Industries, Rubber and Plastics Subdivision of the Process Industries Division, Fuels, Power, Materials Handling, Management, and Railroad. The Committee on Education and Training for the Industries provided speakers for three sessions, and the Special Research Committee on Critical-Pressure Steam Boilers joined with the Heat Transfer and Power Divisions for one session.

A type of session, known as the round-table or panel discussion, at which no prepared papers are scheduled, devoted to some topic of general interest, was used by the Aviation Division, the Management Division, the Power Division, and the Metals Engineering Division.

A few of the technical papers, available well in advance of the meeting, have been published in MECHANICAL ENGINEERING. Others will be published later in this journal and in Transactions. In general the effect of the war has been to delay preparation of papers until too late for preprinting. In many cases the speakers prepared no formal manuscript but spoke extemporaneously. Decision on publication of the results of the round-table discussions is yet to be reached.

Close relationship of the subject matter to the war effort was a feature of a majority of the papers and discussions, and even in cases where the relationship was not direct and immediate it nonetheless existed. It was this factor that accounted for the well-attended sessions and the registration figure of 800 which topped attendance records for Semi-Annual Meetings of recent years.

A less gratifying effect of war conditions was the withholding of a few papers and considerable discussion and technical details because of restrictions imposed by official agencies. For the first time in many years plant trips were virtually abandoned because of the war, and an unfortunate accident to a power cable made it necessary to cancel, at the last minute, the only scheduled trip—that to Nela Park. However, many members were able to arrange privately for personal visits to Cleveland industries.

At least one observer came away with the gratifying impression that it is possible to hold useful and well-attended engineering meetings in wartime, in spite of the fact that mechanical engineers are busier than they have been in a quarter of a century, and that those who did attend were enthusiastic about the quality of the papers and discussions.

Newton and Stout Speak at Luncheons

Two general luncheons, held on Monday and Tuesday, and the Railroad Division luncheon on Wednesday noon, were well attended. At the Monday luncheon J. P. Dearasaugh, of Cleveland, engineer in charge of construction, Aluminum Company of America, presided, and the speaker was Edwin B. Newton, director of technical service, B. F. Goodrich Company, Akron, Ohio. Dr. Newton reviewed briefly the history of the development of the rubber industry and presented some pictures of rubber

A.S.M.E. Officers Are Nominated for the Coming Year

MEMBERS of the A.S.M.E. Nominating Committee for 1942, H. W. Smith, chairman, T. E. Bell, secretary, E. S. Dennison, W. McC. McKee, F. C. Stewart, O. F. Campbell, Julius Billeter, and E. C. Baker have nominated as directors of the Society for 1943 the following:

OFFICE	NOMINEE
President	H. V. Coes
Vice-Presidents	Joseph W. Eshelman
	Guy T. Shoemaker
	Walter J. Wohlenberg
	Thomas E. Purcell (1 year)
Managers	Roscoe W. Morton
	Albert E. White
	Alexander R. Stevenson, Jr.

Biographical sketches of the candidates for office will be published in the August issue of MECHANICAL ENGINEERING.

plantations. He spoke briefly of the synthetic rubbers, of which he showed some samples.

Elmer L. Lindseth, assistant to the president, Cleveland Electric Illuminating Company, presided at the luncheon on Tuesday. William B. Stout, president, Stout Engineering Laboratories, Dearborn, Mich., was the speaker. Mr. Stout gave his audience a glance into the future of transportation, which, he predicted, would develop new and marvelous means of aerial transportation. He expressed great faith in research and in the ability of the younger generation to make revolutionary and far-reaching contributions to engineering and particularly to transportation. He reviewed briefly the amazing exploits and possibilities of the helicopter developed by Sikorsky. Research, he contended, was the basis of the next step in civilization and was the great job to be done in outdesigning the Axis.

Sir Louis Beale Banquet Speaker

On Tuesday evening more than 400 members and guests attended the banquet in the Hotel Statler ballroom where James D. Cunningham, president, Republic Flow Meters Company, Chicago, Ill., was toastmaster. The many distinguished guests at the speakers' table were introduced to the audience by Mr. Cunningham who called upon James W. Parker, president A.S.M.E., as the first speaker. Mr. Parker presented 50-year A.S.M.E. medals to Henry W. Carter, legal and patent department, Owens-Illinois Glass Company, Toledo, Ohio, and William F. Funk, president and treasurer, La Crosse Trailer and Equipment Company, La Crosse, Wis. Following the presentation of the medals Mr. Parker spoke briefly of the mechanical engineers' part under war and post-war conditions.

The principal address of the banquet was delivered by Sir Louis Beale, K.C.M.G., C.B.E., Co-Ordinator of Empire and Allied Requirements, British Supply Council in North America, Washington, D. C. Sir Louis' address will be published in a later issue.

Work of Local Committees Makes Meeting a Success

A well-planned program of excursions, teas, and luncheons was enjoyed by the more than forty women registered at the Semi-Annual Meeting. The program was under the guidance of a committee consisting of Mrs. T. T. Githens and Mrs. Harry Schwartz.

Warner Seeley headed the Committee on Arrangements for the Cleveland meeting as general chairman and Arthur G. McKee served as vice-chairman. To this committee and to the subcommittees formed in the Cleveland area members of the Society are indebted for the smooth operation of the extensive and varied program. The personnel of the subcommittees follows:

Hotel: D. W. Williams, chairman; Warren Brooks, Winston M. Dudley, Lawrence A. Eiben, John C. Geissbuhler, Glenn R. Graham, William A. Lynam, Merritt B. Sampson, Harris A. Squire, and Henry M. Wilson.

Technical Events: T. F. Githens, chairman; C. W. Filman, and C. M. Hickox.

Entertainment: R. E. Erickson, chairman; H. M. Hammond, T. A. Marsh, and R. R. Smith.

Plant Trips: E. M. Messersmith, chairman; C. B. Lansing, E. L. Lindseth, and E. W. P. Smith.

Printing: K. D. Moslander, chairman; Colin Carmichael, Clarence Dauber, and John Stahl.

Finance: H. L. Spence, chairman.

Publicity: L. W. Wallace, chairman; L. E. Jermy, and Robert C. Sessions.

Actions of A.S.M.E. Executive Committee

Meeting at Society Headquarters on May 20

A MEETING of the Executive Committee of the Council of The American Society of Mechanical Engineers was held at the Society headquarters on May 20, 1942. Present at the meeting were James W. Parker, chairman, Clarke Freeman, vice-chairman, G. E. Hulse, C. B. Peck, of the committee; K. W. Jappe (Finance), G. L. Knight (Finance), J. N. Landis (Local Sections), G. B. Karelitz (Professional Divisions); C. E. Davies, secretary, and Ernest Hartford, executive assistant secretary.

John Fritz Medal Board

James W. Parker was appointed a representative on the John Fritz Medal Board of Award to serve a four-year term expiring in 1946.

Production Clinics

Mr. Parker reported that the first Production Clinic, arranged at the request of Donald M. Nelson, chairman, and W. H. Harrison, director of production, War Production Board, was held in Dayton, Ohio, on May 5. Nine additional clinics were held between May 25 and June 9.

Members in the Services

Procedure to be followed in connection with dues of members in the military services was adopted as follows:

"Those members of any grade who are in good standing, or become in good standing as of the time of entrance into the armed services of any of the United Nations, on or subsequent to May 1, 1940, shall have their dues canceled upon approved application, and they shall be carried on an "inactive list" in their proper present membership grades unless advanced until six months after they are mustered out of the service or are removed from the inactive list by action of the Council. This shall not affect the date on which members would become permanently exempt from the payment of dues as provided in the Constitution. Those whose dues are thus canceled shall have their names published in the list of other members but shall not be entitled to receive publications."

It was further voted that the "inactive list" referred to in the foregoing statement of procedure be designated "Service Roll" and that a special membership card be issued to members on this Service Roll.

Co-Operation With S.A.E.

Upon recommendation of the Committee on Professional Divisions, with the concurrence of the Oil and Gas Power Division, approval was voted of extending an invitation to the Diesel Engine Activity of the Society of Automotive Engineers to co-operate in the National Oil and Gas Power meeting, Peoria, Ill., June 17–19, 1942.

Aviation Division Report

A report on the activities of the Aviation Division, December, 1941, to May, 1942, prepared by John E. Younger, chairman of the division, was noted with appreciation.

Deaths of Harrington and Dorner

The deaths, on May 20, of Past-President John Lyle Harrington and, on May 4, of F. H. Dorner, former manager and vice-president of the Society, were reported, and the secretary was instructed to send resolutions to the families of the deceased.

Industrial Conservation

J. N. Landis, chairman of the Committee on Industrial Conservation, reported that a number of agencies in the Society were giving attention to scrap collection and materials conservation. The Committee on Industrial Conservation, of which he is chairman, he said, would serve in a staff function, directing the interests of these agencies in ways that might be fruitful.

Appointments

The following appointments were reported:

Special Research Committee on Forging of Shells, W. P. Muir.

P. T. C. Committee No. 2 on Definitions and Values, G. S. Peterson.

Management Division, General Advisory Committee, G. E. Hagemann.

Northwestern University, dedication new building of Technological Institute, June 15–16, 1942, J. D. Cunningham.

Budget Meeting

The Executive Committee also held a joint meeting on May 20, 1942, at the Society headquarters, with the Finance Committee and representatives of standing and special committees, to discuss the 1942–1943 Society budget.

A.S.M.E.-A.I.Ch.E. Heat-Transfer Symposium Papers Available

THE nine papers presented at the Joint Symposium of the American Institute of Chemical Engineers and the A.S.M.E. Heat Transfer Division, held in Boston, Mass., on May 13, are being published in the Transactions of the former organization, Volume 38, No. 3. This volume, whose contents were listed on page 409 of the May issue of MECHANICAL ENGINEERING, is available to members of the A.S.M.E. at a special price of $1.25. Orders should be sent direct to the Institute at 50 East 41st St., New York, N. Y.

Thousand Engineers Take Part in Newark War-Production Conference

W. H. Harrison, Director of Production, W.P.B., Urges Engineers to Exchange Ideas and Experience

ONE of the series of War Production Conferences sponsored jointly by the engineering societies at the request of the War Production Board was held at Essex House, Newark, N. J., on Friday, May 29, with an attendance in excess of one thousand engineers drawn from the metropolitan area of New York and Northern New Jersey.

The program was under the general chairmanship of R. M. Gates, president of Air Preheater Corporation, who has presided at similar conferences of the series held at Dayton, Bridgeport, Boston, and other industrial centers. During the afternoon a tightly packed general session was addressed by speakers representing industry, the Ordnance Department, the U. S. Army Air Force, and the U. S. Navy.

W. H. Harrison, director of production of the War Production Board, spoke at the dinner at which Myron B. Gordon, vice-president and general manager, Wright Aeronautical Corporation, was toastmaster, before an overflow audience of 800. After the dinner the group split into seven panels for round-table discussion of ordnance inspection, machine-shop problems, metallurgical problems, substitute materials, chemical equipment, and plant safety, and electrical welding and foundry-production problems.

Purpose of the Conference

The Newark conference was one of a series of meetings which were planned after Donald M. Nelson, chairman of the War Production Board, and Mr. Harrison met with the heads of six important national engineering societies. These included: David C. Prince, president of the American Institute of Electrical Engineers; James W. Parker, president of The American Society of Mechanical Engineers; Frederick H. Fowler, president of the American Society of Civil Engineers; Eugene McAuliffe, president of the American Institute of Mining and Metallurgical Engineers; S. D. Kirkpatrick, president of the American Institute of Chemical Engineers; and A. T. Colwell, of the Society of Automotive Engineers.

As a result of this meeting the engineering groups designated Mr. Parker and Mr. Colwell to head a steering committee to arrange for local conferences.

The purpose of the conferences, as decided by the War Production Board and the engineering groups, is "to exchange, examine, and disseminate information and experience on the engineering and management aspects of war-production problems and the change-over of plants and equipment to war production."

C. H. Hescheles Heads Arrangements Committee

The Committee on Arrangements for the Newark Conference consisted of the following, C. A. Hescheles, Brooklyn Union Gas Company, chairman; P. T. Onderdonk, War Production Board, vice-chairman; G. J. Nicastro, Combustion Engineering Company, vice-chairman; B. C. Brosheer, *American Machinist*, McGraw-Hill Publishing Company; H. S. Cord, consultant; H. C. R. Carlson, Lee Spring Company; F. D. Carvin, Newark College of Engineering; E. V. David, Air Reduction Sales Company; F. C. Fyke, Standard Oil Development Company; W. S. Gleeson, American Machine and Foundry Company; Alexander Gobus, Lucius Pitkin, Inc.; S. A. Grucharcz, Monroe Calculating Machine Company; H. Happersberg, Brockway Motor Company, Inc.; W. J. Hargest, *American Machinist*, McGraw-Hill Publishing Company, Inc.; J. H. Head, Chile Coffee Company; J. J. Hogan, Otis Elevator Company; M. P. Hooven, Public Service Electric and Gas Company; W. A. Howard, Socony Vacuum Oil Company; J. H. King, Babcock and Wilcox Company; W. H. Larkin, B. F. Sturtevant Company; W. C. Mearns, International Nickel Company; W. J. Murphy, *Chemical Industries*; J. W. Queen, Joseph T. Ryerson and Son, Inc.; H. Schultz, Carbide and Carbon Chemical Corporation; H. G. Sefing, International Nickel Company; W. J. Shea, New York City Planning Commission; G. W. Strahan, International Nickel Company; H. P. Westman, Institute of Radio Engineers; C. C. Whipple, The Polytechnic Institute of Brooklyn; and J. F. Wyzalek, Hyatt Roller Bearings Division, General Motors Corporation.

15 Organizations Are Joint Sponsors

The conference was sponsored jointly by the following organizations: The American Society of Mechanical Engineers, Society of Automotive Engineers, Army Ordnance Association, American Institute of Chemical Engineers, American Society of Civil Engineers, American Foundrymen's Association, American Institute of Electrical Engineers, American Society for Metals, Society of American Military Engineers, American Institute of Mining and Metallurgical Engineers, Society of Naval Architects and Marine Engineers, Institute of Radio Engineers, American Society of Tool Engineers, American Welding Society, and New Jersey Council.

R. M. Gates Opens Conference

In opening the afternoon session Mr. Gates explained the objectives of the conference and the manner it which it would be conducted. We all had problems in production, he said, which some solved one way and others in another. By means of the conference each man could get the benefit of the experiences of the others so that he could adapt the solutions to his own problem and hence get larger production. The purpose of the conference, he said, was therefore to stimulate production to a faster and more efficient tempo.

Trundle Urges Full Use of Production Facilities

The first speaker was George T. Trundle, Jr., president of the Trundle Engineering Company, whose subject was, "Introduction to the Problems of Conversion." In opening his address Mr. Trundle said: "The failure to utilize to the fullest capacity, now, existing facilities, whether they be buildings or machinery, causes to be built new buildings and new machinery which require new materials, skilled man power, and time, of none of which we have a surplus. Failure to convert your facilities to the job of winning this war benefits no one but our enemies."

He then reviewed broadly the tremendous program of production which lay ahead of the nation and said that this job would put a strain upon the internal and export transportation facilities. The responsibility of getting this production job done lay, in the last analysis, upon the manufacturing enterprises of the United States and upon the men and women now engaged, and who could be engaged in the future, in industrial production. Figuring that it would take 18 persons to provide for each person in the armed forces, it would take ninety million workers to support an army of five million men. Obviously, it would not be possible to find this number of workers and hence it would be necessary to employ older workers. Moreover, it would be necessary to continue manufacture of some peacetime products. These conditions called for "conversion," and conversion was neither easy nor convenient. However, we were at war and if anyone were to complain about conversion, it should be remembered that the foremost example of conversion in the United States was the buck private in the Army.

Conversion, he said, did not mean merely the diverting of materials from peacetime to wartime products or the closing of peacetime plants. It meant utilizing today for war-production purposes all of the plants and facilities of the country. In spite of the steps which had been already taken toward conversion, there was still an enormous amount of equipment in the country not yet in use in wartime production. It was not located in any large quantity in any one place but was scattered throughout smaller manufacturing establishments. Added together there were thousands of machines and facilities which could do war work but which were not now doing it.

One reason why these facilities were not at

work, he said, was because we had started out trying to do most of the war production on new machines. There had been a temptation to wait for new machines before starting war production. It was not possible to wait for these new machines, he insisted. There was not enough time, or materials, or skilled labor. It was necessary, therefore, to use all of the existing equipment today. The assumption that some persons made that the older machines could not be used successfully was not justified by the facts of his own experience.

Mr. Trundle recited cases in which old machines, reconditioned and properly tooled and with the flow of work correctly adjusted, had turned out production at a cost little higher than would have been the case with absolutely new machines. The quickest way of getting the production job done today, he reiterated, was to start to work with the equipment already on hand. By this he did not mean simply the equipment on hand in a contractor's own plant. It might be on hand anywhere in the community, in any plant, large or small, to which a portion of the work might be subcontracted.

In explaining what he meant by subcontracting, Mr. Trundle said that it was naturally impracticable for the government to issue prime contracts to every small manufacturing concern. In many cases, he pointed out, the way to get the job done was to pool the resources of a group of plants in a community on a basis whereby one company was set up as the prime contractor and subcontracts were parceled out among the others. The prime contractor assumed financial responsibility and also responsibility for quality and delivery. It was up to the prime contractor to see that the subcontractor was supplied with complete drawings, specifications, and information about each job. He should use his own men to help get production started in the subcontractor's plant. The chief inspector of the prime contractor should see that the subcontractor was properly instructed in the use of gages, and he should check the gages periodically. The prime contractor should provide inspection in addition to the subcontractor's inspection, inside the latter's plant, to insure quality and avoid waste. In most cases, he said, the prime contractor's plant and equipment were the best fitted for final finishing and assembly operations. It usually possessed capable engineering and production staff and good management.

Negotiated Contracts Explained

Mr. Trundle read the following statement by Houlder Hudgins, acting director of the Purchases Division, W.P.B., relating to the government's present policy of negotiating war contracts instead of placing them by competitive bidding:

"We have recently made a change in our system of procurement, commonly referred to as the negotiation method as against the previous method of low bidder take all. This doesn't actually mean that we negotiate every purchase by a round-table discussion, but it does mean that suppliers who bid relatively high are invited to resubmit a proposal on the basis of an established price. For instance, ten manufacturers might submit bids on a certain item and, under the former method, the lower bidder would get all the business. Under the new method, the bids are arranged from low to high and a sensible price level is picked out and those whose bids are higher than this ceiling price are invited to supply at that price certain established quantities. This gives an opportunity to the high-cost producer to refigure his cost and get some business.

"The motive in making this change to the so-called negotiation basis is to spread the business out over an industry, giving the advantage of geographic distribution, and expediting the delivery of the wanted item. It has already shown that it is an effective means of procurement and one which answers most industry problems.

"Further than that, it would be unwise to go. You can imagine what criticism would be made of a program which raised the price level of procurement as long as suppliers were available at a lower cost. It is our opinion that this criticism would be well founded and that therefore it should be avoided."

Time the Crucial Factor

In closing, Mr. Trundle said:

"In my opinion, industrial concerns who have made their war-production efforts conditional upon the delivery of new machine tools have placed a big additional burden upon the production facilities of the country.

"Of course we have needed vast quantities of new machine tools, and the machine-tool industry has turned them out. We have needed new machine tools to perform work for which there is no counterpart in peacetime production. We have needed certain types of new machine tools for which there has been an especially critical demand.

"But in the face of today's emergency, we should not load up the machine-tool industry with orders for new machines designed to do work of a type which can be done by machine tools already existing on plant floors. We haven't the time, the material, or the trained men to spare for any such unnecessary procedure.

"The crucial factor in this whole picture is the factor of time. I cannot emphasize that too much."

Colonel Clement Talks on Ordnance Work

Following Mr. Trundle as the second speaker Col. J. K. Clement, deputy district chief, New York Ordnance District, U. S. Army, chose as his subject, "Shop Problems in Ordnance Manufacture."

Colonel Clement said that we were called upon "to raise and train the mightiest Army and Navy the world has known, to equip them with the best weapons and most abundant supplies, and, at the same time, to furnish supplies to our allies in tremendous quantities, to build ships and airplanes to carry this Army and its equipment to the enemy, and to maintain it there."

His particular field, he said, was in the production of ordnance matériel for the Army in the New York Ordnance District, which included the northern part of New Jersey and the southern part of New York State. In this district, he continued, "there are outstanding at the present time more than six hundred million dollars' worth of contracts placed by the Ordnance Department." Four years ago, he pointed out, there had not been a dollar's worth of such contracts outstanding, and only three years ago the first Educational Order contracts were placed.

These facts, he contended, bore eloquent testimony to the magnitude of the conversion that had already taken place in his area. These facts also indicated that the fundamental problem in ordnance manufacture was conversion. He cited instances of manufacturers of printing presses and elevator machinery who had become important sources of recoil mechanisms for large-caliber antiaircraft guns. These manufacturers were also producing certain types of machine tools. Another manufacturer of printing machinery was making medium-caliber recoil mechanism and small-caliber cannon. A manufacturer of pneumatic devices was making small-caliber cannon and ammunition. Another manufacturer was turning out substantial quantities of optical and fire-control apparatus. These and other companies, he said, had co-operated with the Ordnance District to survey the field of ordnance matériel and determine what could be produced. To these manufacturers he paid tribute and he made special mention of the companies which had accepted Educational Order contracts.

Three Steps in Ordnance Procedure

There were three steps of particular importance, Colonel Clement pointed out, that were all too often performed in an imperfect fashion. These were: (1) Complete and detailed planning of requirements; (2) the setting of these requirements into a time schedule; and (3) production control. The greatest difficulty he had experienced had been with manufacturers who did not have complete and accurate production records.

The Ordnance Department has been planning for the war for 20 years, Colonel Clement explained. The plans were sound and actual developments had followed them with astonishing closeness. It had not been realized, however, that the United States would become the "Arsenal of Democracy." The result had been a pressure for immediate speed of production of unprecedented magnitude. It was necessary for every critical machine to work 168 hours per week. This need had given rise to new problems of quantity and quality of labor which, in turn, frequently involved agreements with unions. Occasionally, he had met what seemed to be a desire on the part of industry to cling to peacetime production to as great an extent as possible, even to the detriment of war production. Such instances had been few and had been largely overcome in a spirit of co-operation.

Another problem referred to by Colonel Clement arose in connection with contracts on which no cost information had been available for the preparation and checking of bids. These contracts, he said, would be revised in the light of cost experience and prices would be modified when they were found to be out of line. All right-thinking citizens were agreed, he concluded, that no one should secure excessive profits or grow rich from war effort. At the same time, he said, they were equally dis-

posed that all should receive a fair profit for their work.

Aircraft Production Problems

The third speaker, whose subject was "Shop Problems of Aircraft Manufacture," was Lt. Col. A. C. McDonnell, of the District Inspection Office, Eastern Procurement District, U. S. Army Air Force.

Colonel McDonnell said that, in realization of the fact that the present war was not being fought along the methods of the last war, the United States Government had launched the largest military-airplane production program the world had ever known. Inasmuch as the building of a complete airplane involved the complete employment of the arts and skills of 73 different trades and crafts, Colonel McDonnell said he would have to limit himself to the discussion of a few problems only.

The aircraft manufacturer of today, he said, attempted, as far as possible, to turn his factory into an assembly plant and to subcontract the work on airplane parts as much as possible. Airplane parts were not on sale in the market, and all that were needed had to be produced by someone. The small shop was only part of the answer, for the small shop brought many problems of its own into the picture.

Our airplanes were built largely of aluminum and of stainless steel, he said. Wood construction was also used as far as possible on training and cargo planes. All of these materials had, in their turn, brought problems.

Aluminum production had a very difficult job, he explained, to catch up to the airplane builders' needs. Stainless-steel production was somewhat limited because some of its ingredients were critically needed for other war uses. The building of plywood-constructed airplanes was a lost art and had to be revived, and in this revival, new and better methods of employing plastic glues or adhesives were discovered and developed.

The airplane-engine industry, he said, was an example of one that approached the problem skillfully. For some years, most special machine-tool equipment had been accumulated and adequate tooling had been provided. Considerable development and research had been carried on and the recent announcement of a new method of cylinder manufacture was a direct result of this work.

Instrument Production a Problem

The instruments for airplanes had always been difficult to make, he said. Most of them were physical instruments wherein accuracy was dependent upon the elastic qualities of a bellows, a diaphragm, or a Bourdon tube, and consequently, each instrument had characteristics all its own and required the skill of a master instrument maker to adjust and calibrate it. In normal times, the Army Air Forces took delivery of about 300 instruments per month, and no great difficulty was experienced. But now requirements had been expanded so that sometimes 40,000 were accepted in one month.

One of the first problems, he continued, was the shortage of jewel bearings for instruments. These bearings were largely imported from Europe, and there had been two ways of licking this problem. One way was to expand our tiny jewel-bearing industry and another was to substitute other types and kinds of bearings. We had done both; and today we were going along well in this respect.

Another problem had to do with the manufacture of small pinions, shafts, springs, and similar tiny instrument parts.

The problem of optical lenses, prisms, and reticles, was fast being overcome, he said. However, there was still room for the development of optical-glass manufacture and for improved methods of grinding optical glass to mathematical exactness.

There was a great demand for skilled mechanics on general instrument work. This shortage was rapidly being overcome and, to a great extent, was due to the employment of selected women workers, but this employment of women had introduced some unexpected problems.

One of the requirements of successful instrument manufacture was a dust-free shop, and it had been found that the workers carried in considerable dust and lint on their clothing. It was finally found by a microscopic examination of the dust that a portion of it was wool particles. This resulted in an order forbidding the girls to wear sweaters, and this order was much resented. The wearing of facial make-up of any kind was also eliminated in the workroom. Finger-nail polish was found to be especially troublesome when it flaked off into an instrument case. But one by one, these difficulties were eliminated, mainly by explaining that unless these instruments functioned with no impairment of their operating accuracy, it would be difficult for such planes as the "Flying Fortresses" to operate.

Airplane Propellers

There were many shop problems in connection with the manufacture of propellers—both metal and wood construction. Early in the Defense Program, the use of aluminum was avoided in all cases where a substitute was available, and immediately the aluminum propeller loomed large as a target for aluminum economy. The steel propeller, using hollow steel blades, was, however, a difficult production problem. The sheet steel and the hub forgings presented a raw-material problem, just as aluminum did. The manufacturing of the parts, particularly the blades, had to be carefully done so that the finished product would withstand the terrific strains and stresses of service. The control mechanism was a fine machining job. The blades were welded together from sheets, and the heat of welding warped the materials. Annealing, with subsequent aligning and straightening, and final finishing to exact balance and accuracy of curvature presented a big task before the final X-ray examination for possible flaws in the welding seams.

Problems of Naval Procurement

In presenting the final paper of the afternoon session Lt. Com. A. S. Kibbee, U.S.N.R., Office of Inspector of Naval Matériel, divided "Shop Problems in Manufacture of Naval Equipment" into various well-known categories: Finance, research, shop administration, employees, conversion, and "general." He discussed each of these categories and related many instances, typical, and in many cases amusing, which he had encountered in his own personal experiences. In closing he said:

"In general I feel that many of the shop problems that confront manufacturers with respect to turning out equipment for the Navy as well as for ordnance and aviation stem back to the fact that these manufacturers have been taken by surprise in the present situation. We may still think in horse-and-buggy terms.

"Time being of the essence, the professions such as we represent in this meeting can be of inestimable value in helping to solve the problems with speed. Manufacturers want your help now, not six months from now, nor a year from now.

"I feel that the situation presents to us a challenge. Not only a challenge but a privilege. I hope you will all accept both."

W. H. Harrison Endorses Conference Method

Speaking at the dinner which followed the afternoon session, W. H. Harrison, director of production, War Production Board, said that it was his business to work in close contact with production, the pace of which had been set by the vision of the President when he stated the objectives in terms of planes, tanks, and guns. Although he could not mention actual figures, he could say that within broad measure these objectives were being realized. With the war under way by less than six months, already 40 per cent of our economy, or some 3.5 billion dollars per month, was going into it. Despite the fact that last year there had been quantity production of shipbuilding, aircraft, guns, ammunition, explosives, tanks, motorized vehicles, this year, each month, the increment of increase had been 30 per cent greater than in the preceding month. The reason for this striking performance, he maintained, was to be found in the years of careful planning by the armed services and the well-conceived and well-executed organization pattern of design and procurement functions.

Of course, he continued, no one had ever visualized the magnitude of what we were to undertake. The first stage of the program, creation of facilities, was well in hand, the bulk of the facilities being now in place. For those not yet in place, plans were about completed and work was under way. The job that had been done defied description. He predicted that, in history, this performance symbolizing effective teamwork between American industry and American Government would stand out in bold relief.

The second and present stage, he said, revolved around the flow of materials. The cutting off of certain materials from the Far East, plus shipping limitations, had added to the seriousness of the material situation.

The third and coming stage, Mr. Harrison pointed out, which he did not propose to discuss, was man power.

Mr. Harrison paid tribute to the work done by various engineering groups and societies. We were now engaged in group meetings, of which the Newark meeting was one, the purpose of which was to create a round table at which every bit of experience, good and bad, could be discussed. He gave several excellent illustrations of the co-operation of industrial concerns in which technical information had

been interchanged to the advantage of both.

Medium tanks, he said, by way of illustration, were built of steel plate cut to shape and welded together. In building these tanks each of a number of manufacturers had developed different shapes and sizes of plates and used different beveled edges on the plates. Recently, he said, engineers from each of these companies had met in an engineering clinic and had discussed the merits of the shapes used. As a result of this interchange of information, one design was adopted that was suitable for all manufacturers. Specifications had been set up to be used by the steel companies who would now furnish the plates cut to size and shape and beveled to one standard pattern. Another result had been the creation of a standard stock pile from which all manufacturers of tanks could work.

On the broader subject of the pressure for things which grew out of the limitation and curtailment of metals, rubber, and chemicals, he called for charity of understanding and asked his audience not to resent the principle that materials must be restricted. Restriction was a fact, a necessary fact, and a fact "for the duration." "Disagree, criticize, and comment on the mechanisms, the methods, and the frailities of the human beings administering them, if this be your judgment," he said, "but accept the principle."

"One gets the impression," he said in closing, "that we are in for total war. In it Destiny has spelled out a place and responsibility for each of us. No matter how direct or indirect your work is in relation to the conduct of the war, in these group meetings and discussions there is a grand opportunity for extracurricular work.

"Basically, like all other wars, this is a soldier's war. The same strategy, the same principle of weapons, the same courage, the same imagination, the same inspiration that carried on to victory centuries ago will carry it now.

"On the other hand, weapons play a more controlling part than ever before and these are the product of the basic sciences and applied engineering. I have seen what science and engineering have done and are doing. I have seen how unselfish the professions have been and I am very proud of the fact that I stand shoulder to shoulder with my fellow engineers.

"We are grateful to you for giving us a lift."

1200 Attend 7 Panel Meetings

The evening session of the Newark Conference was devoted to seven panel meetings, with a total attendance of 1200, which convened independently, each under the leadership of a specially qualified chairman. For each panel a number of discussion leaders had been selected. According to the plan worked out by the Committee on Arrangements, the secretaries of the panels are preparing résumés of the discussions for the record.

Because of the success of the panel meetings, the A.S.M.E. Metropolitan Section has asked the Committee to proceed with its work with the purpose of forming semipermanent discussion groups so that the subjects may come periodically under review and the benefits of round-table discussion continued.

The chairmen of the panel meetings were as follows:

Ordnance Inspection: F. Malcolm Farmer, vice-president and general manager, Electrical Testing Laboratories, New York, N. Y.

Machine-Shop Problems: P. W. Brown, assistant works manager, Wright Aeronautical Corporation, Paterson, N. J.

Metallurgical Problems: John F. Wyzalek, Hyatt Roller Bearing Division, General Motors Corporation, Harrison, N. J.

Substitute Materials, Chemical Equipment, and Plant Safety: Walter J. Murphy, editor, *Chemical Industries*, New York, N. Y.

Electrical Problems: M. P. Hooven, Public Service Electric and Gas Company, Newark, N. J.

Welding Problems: M. F. Sheeley, Standard Oil Development Company, Elizabeth, N. J.

Foundry Production Problems: F. G. Sefing, International Nickel Company, New York, N. Y.

War Effort Aided by San Francisco Section Meeting on Salvage and Waste Elimination

Another Meeting Sponsored by Junior Group Features Paper Covering the Design and Construction of Warships

SAN FRANCISCO SECTION closed its season for 1941–1942 with the regular monthly meeting held on May 28, 1942, at the Engineers Club. A group of speakers, which included A. H. Richards, regional manager of the industrial salvage section, War Production Board; C. S. McDonald, Standard Oil Company of California; R. A. Watson, Federal Mogul Corporation; W. H. Kassebohm, plant manager, Autometric Machine Tool Co.; and A. K. Ingram, Pacific Gas and Electric Co.; discussed the problems of salvage and the elimination of waste on the industrial front. As a prologue to the meeting, a motion picture, entitled "Mines Above the Ground," was shown.

The speakers explained how the salvage program can be assisted by (1) making one individual in the shop responsible for salvaging material, (2) placing on the bulletin board photographs and catch slogans to stimulate scrap conservation, and (3) notifying other plants through the publications of the W.P.B. and other governmental agencies of obsolete machines and parts, such as cone pullers, lineshaft hangers, etc., which might be used by them.

Of particular interest to the audience, as brought out in the discussion, was the description of the use of electroplated copper bearings in place of Babbitt metal. These, according to Mr. Watson, are working satisfactorily but the maximum temperature at which the new bearing can be used is now being determined by further experiments.

The meeting was adjourned promptly at 9:45 p.m.—the last meeting of the Section until next fall. Announcement was made of the continuance of the regular Tuesday luncheon meeting at the California Hotel in Oakland and members were urged to take part in the discussions announced regularly through the press.

Favorable comment was expressed for the excellent work done by the Professional Divisions Committee of the Section in securing good speakers to present interesting subject matter at the regular Thursday luncheon meetings at the Engineers' Club in San Francisco.

Mr. E. H. Cameron who has served as secretary-treasurer for the last year very thoughtfully arranged a meeting at his own home where the incoming officers will be entertained and introduced to the various procedures of Section work to enable them to prepare the programs for next year.

Junior Group Meeting

The San Francisco Junior Group in conjunction with the Professional Divisions Committee sponsored a seminar dinner on May 7. The speaker of the evening, Lieut. J. E. Flynn, Mare Island Navy Yard, presented an interesting and enlightening discourse on "Warship Design." The talk was sectionalized into several phases in order to permit the audience to discuss each phase separately immediately after its presentation. The portions of the talk covering actual ship-design requirements provoked most interest and discussion. A historical review of dreadnaught development and of general proportioning of defense and offensive weight of typical ships concluded the seminar.

More Than 150 Cleveland Engineers Attend Meeting at Case Observatory

Case Observatory was the scene of the May 21 meeting of Cleveland Section. E. N. Jennison and J. J. Nassau described to the 150 members and guests the engineering features involved in the construction of a telescope. In conclusion the speakers discussed the many applications of the findings of astronomers who use the telescope.

Postwar Planning for Industry Discussed Before Columbus Section

Twenty-five members of Columbus Section were present at Battelle Institute on May 22 to hear John S. Grout, a member of the Institute, speak on "Postwar Planning for Industry." He told of plans now being formulated by manufacturers and governmental agencies for a planned economy to prevent a depression following the war.

President J. W. Parker at Central Pennsylvania Meeting

At a joint meeting of the Central Pennsylvania Section and the Altoona Engineering

Society held in Altoona, Pa., on May 26, the guest speaker was James W. Parker, president of The American Society of Mechanical Engineers, who was introduced by L. B. Jones, engineer of tests for the Pennsylvania Railroad. The 85 members and guests present heard President Parker discuss "The Engineers' Expanding Function."

Final Meeting of Detroit Section Addressed by President Parker

The final meeting of the season was held by Detroit Section on May 5 at the new Rackham Memorial Building. More than 150 members and guests were in attendance. Usually the Section entertains the Student Branches at the final meeting, but owing to present conditions this custom could not be carried out this year. Instead the officers of the Student Branches at the University of Detroit, Michigan State College, and University of Michigan were invited to attend. President James W. Parker addressed the group and gave an account of his travels among the Sections of the Society. He spoke of the intense activity that is going on throughout the country thereby making possible the development of an enormous productive capacity. Among the students, engineers, and soldiers he met there was a deep feeling of confidence and a determination to do their best.

Colonel Henry W. Miller followed him and gave an interesting and instructive talk on conditions leading to war and why human beings become involved. He pointed out that as the population of a country becomes too numerous to support itself on its own land, it must reach out to other lands in order to exist. Optimistically he predicted that the German army would crack up by the end of 1942. With the Germans no longer effective, he expected the Japanese would find themselves pinched between the Russians and the Americans thus leading to the finish of the war by the end of 1943.

All-Day Session Concludes East Tennessee Program

The East Tennessee Section held its final meeting of the year on May 15 in Kingsport, Tenn. Starting with luncheon, the meeting continued in the afternoon with a meeting which featured a motion picture, "Air Raid on Nottingham, England;" an illustrated lecture by M. A. Urquiza, Tennessee Eastman Corporation, on "Our Southern Neighbors;" and another motion picture, "Power by Wright." Following dinner, members saw a motion picture, "Cyclone Combustion," and heard J. S. Herbert, Blue Ridge Glass Corp., discuss "What's New in Glass Making?"

Fort Wayne Section Learns About Induction Hardening

Dr. Harry B. Osborn was the speaker at the May 14 meeting of the Fort Wayne Section. Illustrating his talk with slides, he discussed the process of hardening surfaces of steel parts by the Tocco method. Parts such as crankshafts are surface-hardened only at the journals by induction heating and water quenching. The process is fast, causes no distortion or scaling, and produces a very good metallic structure.

Oil From Sand Discussed at North Texas Meeting

At the May 19 meeting of North Texas Section, the speaker was James A. Lewis, Core Laboratories, Inc. By means of slides, he gave an interesting paper on the use of core samples in determining if a particular sand would be productive in oil and suitable for gas-expansion or water drive. Graphs, data, and formulas showing influence of permeability, viscosity, porosity, etc. were given and explained.

Engineers in Ontario Learn About Springs

R. W. Cook, Wallace Barnes Co., presented a paper on May 14 before 50 members and guests. Entitled "Springs—Design and Application," his talk covered the theory of spring design and problems of manufacture. Their application to modern warfare was outlined and featured the importance of close tolerances and extreme fatigue circumstances.

Philadelphia Spring Outing Enjoyed by More Than 200

The annual spring outing of Philadelphia Section held on May 26 proved very successful if the attendance of 200 is any criterion. Held at the Cedarbrook Country Club, the session featured a golf contest, bridge, and the annual dinner. About 54 members played golf in the afternoon and Benjamin W. Webb won the Section Cup from Walter Gavitt, last year's winner. Under the chairmanship of Mrs. C. W. E. Clark, the women played bridge. At the dinner held in the evening, J. Stanley Morehouse, retiring chairman, presented the new officers for the coming year.

Southern California Talks by Engineer and Psychologist

More than 75 members and guests of Southern California Section were present at the May 14 meeting held in Los Angeles. W. H. Sullivan, engineer, Westinghouse Electric & Manufacturing Co., gave an illustrated lecture on the design and construction of turbines. Dr. H. M. Baker, eminent psychologist, presented a paper on the methods utilized in choosing the right man for the job.

The Southern California Junior Group on May 1 sponsored a meeting at California Institute of Technology which was addressed and attended by student members from the Institute and the University of Southern California. Rolf H. Saborsky spoke on "Experimental Investigations of the Hydraulic Jump," Edward Lawlor on "The Two-Stroke-Cycle Airplane Engine," and Jack L. Alford on "Fuel Injection in Aircraft Engines."

Problems in Use of Coal Discussed at West Virginia

At the April 28 meeting of the West Virginia Section, E. G. Bailey, vice-president of Babcock & Wilcox Co. spoke on "Some Important Problems in the Use of Coal." He pointed out how the railroads and the coal mines and their operators have come into importance through the needs of the war. This has been brought about because of the scarcity of oil and gas. Even though coal is plentiful, he stated, it should be used wisely and safely because of two reasons: first, conservation of fuel and time, and second, care will eliminate costly shutdowns. Mr. Bailey gave many very helpful and timely suggestions and hints for bettering the operation of boilers. More than 65 attended the meeting.

Worcester Section Members Welcome President Parker

"A.S.M.E. Faces a Fork in the Road" was the title of the paper presented by James W. Parker, president of the Society, before an enthusiastic audience at the May 14 meeting of Worcester Section. He showed how the Society and its membership must decide for themselves their place in the postwar program.

Engineers Using Photostat and Microfilm Service

Growing demands on the photostat and microfilm services of the Engineering Societies Library, New York, indicate that these processes for reproducing documents are attracting more and more attention from day to day. Orders for these services are twenty-five per cent greater this year than last.

In addition to requests for a single article one or two pages long, orders calling for hundreds of prints come in the Library report. It has been found that many establishments build up files of all articles relating to their work instead of collecting sets of periodicals. In this way much space is saved by the elimination of irrelevant material, and what is wanted can be filed according to personal wishes.

Both methods of copying have their advantages. Photostats resemble ordinary documents. They can be filed in the same way, in letter files or loose-leaf binders. Several can be spread out and consulted simultaneously. Other documents can be interfiled with them.

Microfilm copies are cheaper and, when long articles or whole books are to be copied, the saving is large. To use them, some projection apparatus or reading machine is necessary. These machines are as yet not common office equipment, and good ones are rather expensive, costing about what typewriters do. Film is not as easy to store and handle as photostats are.

Up to now, most members of the engineering societies who use the Library seem to prefer photostat copies. The Library is ready at all times to supply either photostats or microfilms, as desired.

VIEW OF THE NEW $5,000,000 BUILDING OF THE TECHNOLOGICAL INSTITUTE OF NORTHWESTERN UNIVERSITY, EVANSTON, ILLINOIS, SHOWING FOUR OF THE SIX WINGS

(More than 500 ft wide and 342 ft deep, it has a floor area of 423,000 ft, which makes it one of the largest educational buildings in the world. The exterior is of Lannon stone, with Indiana limestone trim. Modern Gothic architecture is used, to conform with other new buildings on Northwestern's Evanston campus. It has the appearance of two letter E's placed back to back and joined by a four-story central structure. It contains more than 350 rooms, used by the departments of physics, chemistry, and civil, mechanical, electrical, and chemical engineering.)

Technological Institute Dedicated at Northwestern

Curriculum Covers Five-Year Period and Operates on Co-Operative Plan

ON June 15 and 16 the Technological Institute of Northwestern University, Evanston, Ill., built at a cost of $6,375,000 through the generosity of Walter P. Murphy, president of The Standard Railway Equipment Company, was dedicated with appropriate ceremonies. James D. Cunningham, president, Republic Flow Meters Company, represented The American Society of Mechanical Engineers.

The building, which contains 10 acres of floor area, is 500 ft wide and 342 ft deep. Its general arrangement is that of two letter E's laid back to back and joined by a central structure. The center is occupied by the main auditorium, lecture rooms, the library, the student lounge, and the main offices. Each of the six wings houses one of the major divisions, the departments of physics and chemistry of the College of Liberal Arts and the departments of civil, chemical, electrical, and mechanical engineering of the Institute.

Ovid W. Eshbach, Dean

Shortly after the announcement was made of Mr. Murphy's gift which brought the Institute into being, Ovid W. Eshbach was selected as its dean. The Institute was opened in the fall of 1939 with an enrollment of 97 students. This year the enrollment was brought to 520 students. During the next few years this will be increased to 900, which is regarded as the optimum for present facilities.

The Technological Institute operates on the co-operative plan. Under this system students are required to alternate three months of study with an equal period in industry. The curriculum covers a period of five years. The first year is spent entirely in college, and the summer following is a vacation period. In the second year the students begin their quarterly alternation between classroom and industry. Half the class remains in college while the other half goes into the plants for the fall quarter. This alternation continues until the spring quarter of the senior year, when the entire class is brought into the college.

North-Central Wing—Mechanical

The north-central wing of the Institute building is occupied by the department of mechanical engineering with 34,000 square feet of floor space, mostly devoted to laboratories. Heat-power and thermodynamic equipment units are located on the basement and first floor. The main laboratory on the first floor is designed for the testing of mechanical equipment. Also on the first floor is a controlled-temperature laboratory containing about 700 sq ft of floor space in which a complete air-conditioning equipment provides any temperature from —20 F to 150 F. In the basement are a service machine shop and a low-temperature laboratory constructed to produce temperatures as low as —75 F. Four special rooms have been built for testing internal-combustion engines and fuels. The second floor is devoted to shopwork and the materials of manufacture and contains a pattern shop, foundry, machine-tool laboratory, a welding and heat-treatment laboratory, and a metallography laboratory.

MACHINE-TOOL LABORATORY IN THE MECHANICAL-ENGINEERING DEPARTMENT OF THE NEW TECHNOLOGICAL INSTITUTE OF NORTHWESTERN UNIVERSITY

Handbook of Scientific and Technical Societies and Institutions

THE National Research Council has recently issued the fourth edition of a "Handbook of Scientific and Technical Societies and Institutions of the United States and Canada" (N. R. C. Bulletin No. 106, January, 1942; 389 pages). The United States section contains information on 1269 societies, associations, and similar organizations in the natural sciences and related fields that contribute to the advancement of knowledge through their meetings, publications, and other resources. There are also included a number of more general organizations and special institutions supporting scientific research, as well as the constituent or affiliated societies of the three other national research councils of the United States—the American Council of Learned Societies, the American Council on Education, and the Social Science Research Council. The Canadian section, compiled through the co-operation of the National Research Council of Canada, contains information concerning 143 organizations.

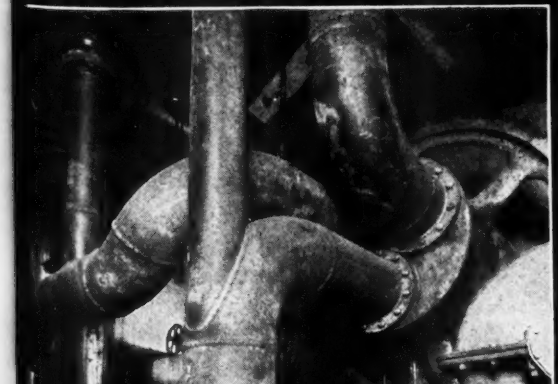
The Handbook gives, in most cases, the president and secretary of the organization; the history, object, membership, meetings, research funds, and serial publications. A subject index to each section (United States and Canada) includes a classification of the activities, funds, periodicals, and changes of name as reported in the history. The fourth edition has a personnel index also for each section.

The information for the fourth edition was furnished during the period from July 1, 1941, to January 15, 1942, by the organizations. It is for sale by the National Research Council, Washington, D. C., price $4.

(*A.S.M.E. News continued on page 576*)

Constant jams at the turns upset piping systems, too!

WELD WITH TUBE-TURN FITTINGS TO SOLVE TOUGH PIPING PROBLEMS



In this process industrial plant, the double problem of complete protection against leakage and other possible piping failures plus the necessity of a compact piping layout, is easily solved with Tube-Turn welding fittings. Tube-Turn fittings offer the advantages of greater strength and safety, faster installation, less weight, less pressure loss, less space occupied, and a full line of fittings for every welding piping need.

Tube-Turn Welding Fittings protect your piping where it counts most!

At a roller derby, people rush to get seats near the turns for the thrills are there! It's at the turns where the speeding skaters bunch up and try to cut off opponents—it's here where crowding the turns means trouble. The same hazard exists in piping systems at the turns, for pressure and strain are proportionately increased wherever flow direction is changed. That's why welding with Tube-Turn fittings is the best possible protection against piping failures occurring where the danger is greatest—*at the turns.* There is a Tube-Turn welding fitting for *every* piping turn!

Write for helpful Tube-Turn data book and catalog.

Tube Turns, Inc., Louisville, Ky. *Branch offices:* New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Tulsa, Houston, Los Angeles, Washington, D. C. *Distributors in all principal cities.*

TUBE-TURN TRADE MARK — The FIRST Welding Fittings 1st And Still the Best — *Welding Fittings*

Engineering Societies Personnel Service, Inc.

These items are from information furnished by the Engineering Societies Personnel Service, Inc., which is under the joint management of the national societies of Civil, Electrical, Mechanical, and Mining and Metallurgical Engineers. This Service is available to members and is operated on a co-operative, nonprofit basis. In applying for positions advertised by the Service, the applicant agrees, if actually placed in a position through the Service as a result of an advertisement, to pay a placement fee in accordance with the rates as listed by the Service. These rates have been established in order to maintain an efficient, nonprofit personnel service and are available upon request. This also applies to registrants whose notices are placed in these columns. All replies should be addressed to the key numbers indicated and mailed to the New York office. A weekly bulletin of engineering positions open is available to members of the co-operating societies at a subscription of $3 per quarter or $10 per annum, payable in advance.

New York	Boston, Mass.	Chicago	Detroit	San Francisco
29 W. 39th St.	4 Park St.	211 West Wacker Drive	100 Farnsworth Ave.	57 Post Street

MEN AVAILABLE[1]

MATHEMATICAL ENGINEER, 37, outstanding theoretical background in applied mathematics: mechanical, electromechanical, and physical fields. Seven years' academic research experience, two Ph.D.'s, 3 years' practical experience with large industry. Me-757.

MECHANICAL ENGINEER, 28, 5 years' development work with large chemical company, experienced many types chemical-plant equipment. Honor graduate Eastern University. Want connection with chemical or process industry. Married, draft 3-A. Me-758.

MECHANICAL ENGINEER, 49, young, clean-cut, aggressive, excellent background chief and industrial-plant engineer, power engineering, and operating. Competent executive well-grounded in fundamentals, employed, desires change. Prefer eastern location. Me-759.

PROFESSOR OF MECHANICAL ENGINEERING, 57 years old, 30 years' teaching experience. Outstanding teaching. Perfect health. Specialties: Thermodynamics, steam power, dynamics of machinery. Wishes to make change. Location preferred, East, but will consider other locations. Me-760.

SALES ENGINEER, graduate mechanical. Experienced in heavy machinery and Diesel equipment of all kinds. Large following in South and Southeast. Selling organization established. Seeking direct connection or manufacturer's representation. Me-761.

ERECTION AND MAINTENANCE ENGINEER, 20 years' experience; graduate mechanical engineer, thoroughly acquainted Diesel general equipment marine and stationary, machine shop. Several years port engineer. Contract fulfilled in South America, returning States 30 days. Want connections; location optional. Me-762.

POSITIONS AVAILABLE

PATENT ATTORNEY. Must have law degree and engineering background, preferably mechanical. Salary open. Northern New Jersey. W-512.

[1] All men listed hold some form of A.S.M.E. membership.

ESTIMATOR, about 45, to take off quantities on reinforced-concrete tanks and elevating machinery. Permanent. $4160 year. Location, New York, N. Y. W-516.

SUPERVISOR OF TRAINING, about 35, graduate, to develop and administer training programs for foremen and supervisors and help these men train their operators. Will eventually extend his activities. Would prefer man who had been working in large company with orderly training and personnel programs. Permanent. $5000–$6000 year. Pennsylvania. W-531.

MECHANICAL ENGINEER with experience in design of electrical connectors, such as plugs, sockets, and similar small parts. Should be capable of handling development and design of such parts and of following through their manufacture. Pennsylvania. W-539.

MECHANICAL ENGINEER, 30–35, for general plant-maintenance work. Experience in chemical plant including generation of steam and power very desirable. $3600 year. New Jersey. W-544.

DRAFTSMEN, two, mechanical preferred, with minimum of 5 years' experience. Need one man capable of designing and detailing complete project from rough sketches; should have some practical experience in shop methods. Other man should be good detailer with practical experience. One hundred per cent defense work. Salaries open. New Jersey. W-561.

PRODUCTION ENGINEER with good practical background in machine-tool operations. Man who can detect inferior machining methods and suggest improvements. Must be able to step up production. Permanent. $5000 year. New York, N. Y. W-565.

VALVE MANUFACTURING ENGINEER, experienced in both practice and theory of safety-valve manufacturing processes and design fundamentals. Will act as assistant to engineering and manufacturing departments in matters of design and methods. Write letter of application, stating full details, including salary desired and date available. Permanent. New England. W-578.

PLANT-OPERATING FOREMAN, about 45. Must know machine-tool operations and be capable of instructing operators in their proper use. Will be responsible for building up operating organization to handle jobs from small drill press to 72-in. boring mill on close-tolerance cast-steel products. $3600 year for 48-hour week. Middle West. W-602-CD.

ASSISTANT PROFESSOR OR ASSOCIATE PROFESSOR, for department of mechanical engineering, to teach aeronautical engineering. Must have master's degree in aeronautical engineering, as well as some teaching and practical experience. Will teach aircraft structures and stress analysis and other subjects. $4500 per 10-month academic year. East. W-605.

PRODUCTION ENGINEERS with background in consumer-goods industries. Prefer men with experience in more than one line. Should know plant-machinery capabilities and be able to adjust layout to accommodate new products. Knowledge of merchandising desirable. $3800–$5600 year. East. W-609.

MECHANICAL ENGINEERS. (*a*) Background of designing nature. Will do actual drawing and designing, but will be above draftsman's status. Will be in charge of project with assistance and supervision of chief and assistant chief engineer. (*b*) Draftsman experienced in product engineering and design. Should be able to detail lightweight castings, and sheet-metal parts. Should have worked on precision objects with fairly close tolerances for design of small objects, small parts, and small pieces of machinery. Preferably 4 or 5 years' experience. Salaries, including overtime at time and a half, $3300–$4944 year. Delaware. W-615.

INSPECTORS with machine-shop background, considerable knowledge of gages and verniers, Rockwell testing machines, etc. Should know enough about engineering to be able to compare actual assembled parts with blueprints and check for accuracy. Prefer men who have done considerable work with gears. Delaware. W-616.

MAINTENANCE ENGINEER, electrical, with thorough all-around experience in plant electrical maintenance, such as lighting, power, communications, rotating-machinery repair, etc. Must be able to assume full responsibility for keeping electrical apparatus in good working condition. $4500 year. New York, N. Y. W-618.

MECHANICAL ENGINEER, to 50, with 10 years' experience. Should have factory background in material-handling field, design, application of commercial and special material-handling equipment, such as electrical trucks, cranes, conveyers, hand trucks of various kinds, special trays, etc. $3600 year and up. New Jersey. W-620.

INSTRUCTOR with some knowledge of machine-shop methods to teach mathematics and mechanical drawing. Classroom work takes up about half time, remainder being spent in one of shop rooms handling numerous details of incoming and outgoing work, assigning jobs, and instructing apprentices; 50-hour week. Connecticut. W-630.

MECHANICAL AND ELECTRICAL ENGINEERS, graduates or 1 to 10 years' experience, preferably in planning for manufacture of small mechanical or electrical apparatus. Work involves analyzing manufacturing data and drawings, making tool and machine analyses and

(*A.S.M.E. News continued on page 578*)


Anytime
IN WAR OR PEACE—
you can depend on Morse Silent and Roller Chain Drives to provide capacity and stamina to keep maximum production rolling, free from costly maintenance or breakdowns.
Reliability and high efficiency in capacities from fractional to thousands of horsepower.
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manufacturing layouts, which requires specific knowledge of machines, machine tools, punches, and dies. Normal 5-day week, sixth day, overtime pay. Maryland. W-631.

ASSISTANT FACTORY MAINTENANCE ENGINEER, preferably electrical, as all machines in plant are individually motor-operated. Company would like to improve electrical power condition in plant. Some knowledge of heat and ventilation also desirable. $3900 year. Defense work. Connecticut. W-633.

MECHANICAL ENGINEER, young, capable of assuming responsibilities and looking for opportunity to increase effectiveness. Should have had 5 to 12 years' experience in power and industrial process plant design, heat-balance computations, specifications, and project engineering. Experience with large engineering company or equivalent desirable. Starting salary, about $5000. Pennsylvania. W-646.

BUSINESS SPECIALISTS for government work. Should have knowledge of any one of following industries: Machine-tool equipment, construction and mining equipment, process, electrical, transportation, or general and auxiliary equipment, or parts and subassemblies. $3200–$4600 year. Washington, D. C. W-672.

ASSISTANT SUPERINTENDENT OR SUPERINTENDENT of a medium-sized machine shop. Should have broad general machine-shop supervisory experience. $5200–$6500 year. Connecticut. W-652.

MACHINE SHOP SUPERINTENDENT. Must have actual shop experience and worked through apprentice course. Must know machine operations. Man now assistant to shop supervisor, capable of directing workers will qualify. Salary open. Northern New York State. W-662-D.

FACTORY MANAGER for 600-employee plant. Must be thoroughly acquainted with large tool work. Must be good executive and able to direct plant personnel. Some practical experience on boring mills, planers, etc. would be beneficial. Ohio. W-668-CD.

CHEMICAL OR MECHANICAL ENGINEER with at least 10 years' experience in design and layout of chemical plant and equipment. $4600 year. Suburban Pennsylvania. W-671.

A.S.M.E. War Production Committee Reorganized

THE War Production Committee (formerly the National Defense Committee) of The American Society of Mechanical Engineers was recently reorganized and the scope of its activities has been enlarged. The personnel of the committee is as follows: James L. Walsh, chairman; Rear Admiral J. A. Furer, representing the U. S. Navy; Col. T. D. Weaver, representing the U. S. Army; R. M. Gates, representing the Engineers Defense Board; the following representatives of A.S.M.E. professional divisions: K. H. Condit (Management), C. F. Dietz (Materials Handling), Sol Einstein (Production Engineering), D. S. Ellis and W. M. Sheehan (Railroad), A. R. Stevenson, Jr. (Aviation), and T. H. Wickenden (Metals Engineering); and the following: W. L. Batt, C. E. Brinley, H. V. Coes, H. N. Davis, W. C. Dickerman, Gano Dunn, W. F. Durand, R. E. Flanders, K. T. Keller, David Larkin, F. T. Letchfield, T. A. Morgan, R. C. Muir, E. A. Muller, T. E. Murray, W. I. Westervelt, and A. C. Willard.

Candidates for Membership and Transfer in the A.S.M.E.

THE application of each of the candidates listed below is to be voted on after July 25, 1942, provided no objection thereto is made before that date, and provided satisfactory replies have been received from the required number of references. Any member who has either comments or objections should write to the secretary of The American Society of Mechanical Engineers immediately.

KEY TO ABBREVIATIONS

Re = Re-election; Rt = Reinstatement; Rt & T = Reinstatement and Transfer to Member.

NEW APPLICATIONS

For Member, Associate, or Junior

ABBOTT, HORACE P., Baltimore, Md.
ALEXION, JOHN, Woodside, N. Y.
BASCI, JOSEPH, Brooklyn, N. Y.
BRADLE, ROBT. C., Brooklyn, N. Y. (Rt)
BECKER, CARLTON H., Lombard, Ill.
BENTON, EUGENE D., Louisville, Ky.
BIDDLE, RALPH W., Vandalia, Ohio
BILYK, MATHEW H., Baltimore, Md.
BOGUE, JOSEPH C., Boston, Mass.
BOOTH, ROBT. L., Bethany, Conn. (Re)
CARABITSES, NICHOLAS L., Boaton, Mass.
CARLSON, DAVID, Woodstock, N. Y. (Re)
CARSTARPHEN, CHAS. F., Bremerton, Wash.
CHAMPLIN, DONALD W., Defiance, Ohio (Rt & T)
CLEAVER, WM. H., Audubon, N. J. (Rt)
DANN, DONALD A., Vatukoula, Fiji
DAWIDOWICZ, WM. J., Brooklyn, N. Y.
DONG, JAS. C., New York, N. Y.
DOWNS, JAS. B., Houston, Texas
DYKE, THEO. A., Jackson Heights, N. Y.
FEDUK, MICHAEL, Philadelphia, Pa.
FITZGERALD, LIEUT. JAS., Miami, Fla.
FOURNIER, JOHN A., Milwaukee, Wis.
GALLAGHER, JOS. W., Kansas City, Mo.
HADDOX, LOUIS C., Madison, Wis.
HARMON, ROBT. H., Ancon, C. Z.
HEARN, HAROLD E., Trinidad, B. W. I.
HEATER, CHAS. L., Flossmoor, Ill.
HENDERSON, JAS. M., Alcoa, Tenn.
HILLER, JOHN D., Phoenix, Ariz.
HOLTORP, CARL H., New York, N. Y.
HUMMER, RALPH G., Defiance, Ohio
JOHNSON, SIGURD O., Buffalo, N. Y. (Re)
JONES, K. K., Pleasantville, N. Y. (Rt)
JUNKER, WM. H., Cincinnati, Ohio
KAMPTNER, GUSTAV, Denver, Colo.
KATTELMANN, HARRY R., Oakland, Calif.
KEELING, HARRY J., Los Angeles, Calif.
LAZZARO, VITO, Waterbury, Conn.
LEO, YUEN B., Chicago, Ill. (Rt)
LE PAIGE, LEON G., New York, N. Y.
MAXFIELD, HORATIO W., New York, N. Y. (Rt)
MC CATHRON, CLAUDE B., Rochester, N. Y.
MIKOVEC, JOHN S., Omaha, Neb.
MITCHELL, WM. M., Wyandotte, Mich. (Rt)
MOIR, HARRY L., Chicago, Ill.
NEEDHAM, PAUL E., Watertown, N. Y.
PEASE, IVAN R., Middletown, N. Y.
PONZEK, JOS. A., Watertown, N. Y.
POOSER, ARTHUR K., Pisgah Forest, N. C.
PRANDONI, JOS. F., New York, N. Y. (Rt & T)
REINHARDT, ALBRECHT E., E. Milton, Mass. (Re)
RINEHART, JAS. A., Jackson, Mich.
ROBINS, JOHN W., Fairfield, Conn.
ROBINSON, PARKE D., Minneapolis, Minn.
ROCHESTER, WM. L., Oyster Bay, N. Y.
ROSEBROUGH, JOHN D., Detroit, Mich. (Re)
SCANLON, JOHN J., Utica, N. Y. (Rt & T)
SCHWARTZ, DANIEL M., Pittsburgh, Pa.
SELDEN, DUDLEY, Erie, Pa. (Rt)
SOMERS, JOHN C., Jackson Heights, N. Y. (Rt)
STEINBRENNER, GEO. R., Niagara Falls, N. Y.
SUTTON, WALTER C., Shaker Heights, Ohio
SWEM, GEO. A., Hollywood, Calif.
TYLER, WALTER D., Watertown, N. Y.
VAN VALZAH, ROBT. W., Chicago, Ill.
WOODRUFF, S., Bronxville, N. Y.

CHANGE OF GRADING

Transfer to Fellow

LARNER, CHESTER W., Philadelphia, Pa.

Transfer to Member

LOSS, ISIDOR R., Rowayton, Conn.
WAITKUS, JOS., Wellsville, N. Y.

Transfers from Student-member to Junior—440

A.S.M.E. Transactions for June, 1942

THE June, 1942, issue of the *Journal of Applied Mechanics*, contains:

TECHNICAL PAPERS

- Steady Flow in the Transition Length of a Straight Tube, H. L. Langhaar
- Model Tests of Two Types of Vibration Dampers, C. A. Meyer and H. B. Saldin
- Self-Excited Oscillations in Dynamical Systems Possessing Retarded Actions, Nicholas Minorsky
- Torsion of Multiconnected Thin-Walled Cylinders, F. M. Baron
- A Simple Air Ejector, J. H. Keenan and E. P. Neumann
- Graphical Solution of Fluid-Friction Problems, E. S. Dennison
- Correlation of Residual Stresses in the Fatigue Strength of Axles, O. J. Horger and H. R. Neifert
- Plastic Flow as an Unstable Process, L. H. Donnell

DISCUSSION

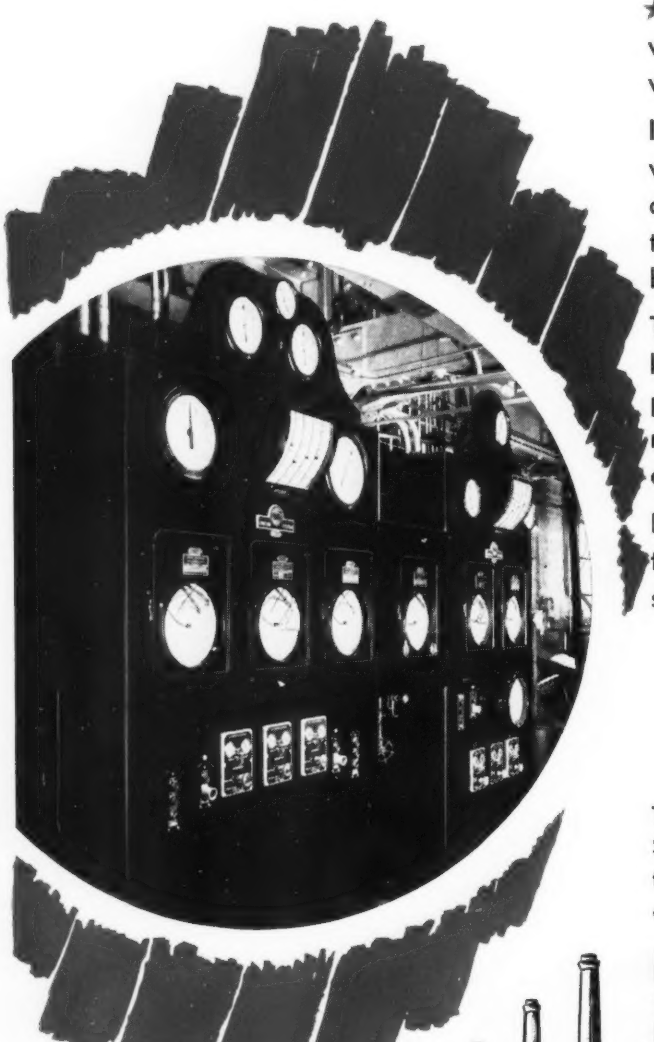
- On previously published papers by M. A. Sadowsky; R. Schilling and H. O. Fuchs; A. M. Wahl; W. M. Dudley; and Nicholas Minorsky

BOOK REVIEWS

MECHANICAL ENGINEERING

August 1942

ARMS FOR THE BATTLE OF PRODUCTION



★ This is a mechanized war. Battles are being won by hard-fighting men who are well armed with modern equipment.

In the battle of production the boiler operator whose effectiveness is multiplied by Bailey Meters and Control is like the machine gunner who rides to battle in a jeep, tank or airplane. Both men are better able to serve because they use modern arms.

To win the battle of production, boilers must be kept in almost continuous service, maximum capacities must be secured, fuel must be conserved, men and equipment must be protected against accidents, and new manpower must be trained.

Baily Meters and Control are helping to win this battle. They are modern arms for boiler room soldiers. By their use power engineers are able to:

1. Avoid frequent shutdowns for maintenance.
2. Stretch steaming capacity.
3. Reduce consumption of fuel.
4. Insure safety of men and equipment.
5. Maintain efficiency while training new operators.

Their use is explained in the bulletin "How to Safely Stretch Steaming Capacity", which offers suggestions for the solution of many of today's problems. To obtain a copy simply ask for Bulletin No. 16. A-84-1

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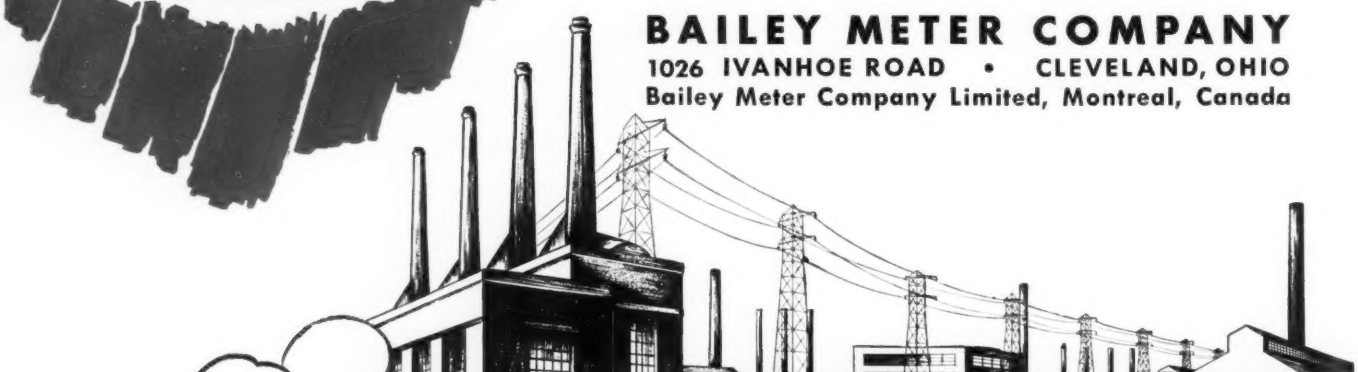

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MECHANICAL ENGINEERING

Published by The American Society of Mechanical Engineers

VOLUME 64 — NUMBER 8

Contents for August, 1942

Published monthly by The American Society of Mechanical Engineers. Publication office at 20th and Northampton Streets, Easton, Pa. Editorial and Advertising departments at the headquarters of the Society, 29 West Thirty-Ninth Street, New York, N. Y. Cable address, "Dynamic," New York. Price 75 cents a copy, $6.00 a year; to members and affiliates, 50 cents a copy, $4.00 a year. Postage outside of the United States of America, $1.50 additional. Changes of address must be received at Society headquarters two weeks before they are to be effective on the mailing list. Please send old as well as new address. . . . By-Law: The Society shall not be responsible for statements or opinions advanced in papers or . . . printed in its publications (B13, Par. 4). . . . Entered as second-class matter at the Post Office at Easton, Pa., under the Act of March 3, 1879. . . . Acceptance for mailing at special rate of postage provided for in section 1103, Act of October 3, 1917, authorized on January 17, 1921. . . .

H. Armstrong Roberts

"Let's Go!"

Volume 64
No. 8

MECHANICAL ENGINEERING

August
1942

GEORGE A. STETSON, *Editor*

Lessons of War

UP to the present time the average citizen with a few dollars in his pocket has had little difficulty in purchasing ordinary articles for his daily needs. Indeed, he can still buy equipment for his home that will cost him more than a few dollars. He can't freely purchase a 1942 automobile or tires for the older models. He is rationed for sugar purchases and, in some states, for gasoline. In fact, the effect of the conversion to war production of hundreds of plants making articles for peacetime consumption has hardly been felt, as yet, because we are living on the inventories built up in warehouses and stores all over the nation. As these stocks are moved on to individual purchasers, the pinch will be felt in many places and we shall realize what it means to go without even when we have money with which to make purchases.

Everyone knows what is causing the pinch. Our armed forces, and those of our allies, require in prodigious quantity an amazing variety of goods and equipment. We face a shortage of materials, not only because of increased production but also because of the shutting off of normal sources of supply. Our machinery is busy; our plants are converted into war production; and our labor market has been scraped of every available person with skill and health to work. What can be spared from the war effort in the way of materials, machinery and plants, and man power will have to serve as best it can our normal needs. Substitution, reclamation, conservation, and simplification must be ingeniously applied. Output of machines and men still left in normal production must be increased if we are to avoid the serious shortages already forced upon other nations.

These rapidly advancing shortages have their compensations. The homely and almost discredited habit of thrift is again becoming one of the virtues practiced by prudent persons. Ingenuity is at a premium. Wits are sharpened. Production techniques are improved. In spite of the tremendous waste of war we are learning how to increase our production efficiency in every department. Surely, when peace comes, we shall be in a better position to provide the goods and services necessary to raise the material standard of living of all our people than we were before the need for learning these useful lessons was forced upon us.

It is the particular province of the engineer to meet the challenge of present necessity with all the skill at his command. All over the world he is communicating to others his mastery of production. Sir Louis Beale, in the Cleveland dinner address published in this issue, cited the case of the garages in the vicinity of Tunbridge Wells that have been organized to take over an important task of war production. Can it be doubted that men and women with the latent energy and resourcefulness to put themselves to work under the pressure of wartime necessity will be content to suffer in peacetime from a lack of production they have convinced themselves it is within their power to contribute? Will the realization of the fact that ordinary men and women can unite their efforts to help themselves under the spur of desperate conditions vanish when it becomes no longer necessary to make instruments of defense and destruction? Will it not be difficult to convince such people, who have labored valiantly to preserve their freedom to work and live under a war economy, that there are valid reasons for their ever, in a peace economy, submitting to the deadening restrictions of unemployment and privation?

The men and women of free nations represented by those organized in the garages of Tunbridge Wells to save their right to live and work are today able to take a hand in their own destinies because of a necessity born of war. A unity of objective holds them together under the co-ordinated economy imposed by their leaders. The objective of a threatened freedom is sharp, clear-cut, and easy to comprehend. It inspires self-sacrifice for the common good which makes individual welfare secure. Even in war it cannot be attained without wise national leadership and intelligent application, in local units, of intelligent management. If free nations learn this lesson from the war, there need be little concern that we shall ever return to a peacetime economy with a confusion of objectives, a catch-as-catch-can muddle of management, and a frustration of human happiness because of destructive self-interest. When we shall feel justified in demanding a new supply of the goods fast disappearing from our present stocks we shall, if we are wise, remember that we organized our productive energies for war; and we must then convince ourselves that we can do the same thing in days of peace.

Extension of the Art of Management

ENGINEERS know that it takes more than materials, money, men, and machinery to make a profitable enterprise. At least management and markets must be added. Management is a very ancient art in its broad sense, which may include everything from bossing a crew of a few men to handling the affairs of a group of interrelated industries. Modern management, as it applies

to our productive industrial enterprise, is a highly developed art to which we attempt to apply the scientific method on the one hand with a practical knowledge of human nature on the other. Engineers have been successful in this field, developing it, indeed, as a specialty to such an extent that, under conditions of corporate ownership, they have taken over the function formerly performed by individual owners of enterprises. In this capacity they have joint responsibilities to the legal owners, the employed personnel, and the public, and upon the successful discharge of these responsibilities rests the success of the enterprise. However, the engineer's scientific and engineering objectivity must be quickened by a keen sense of human values to be wholly effective. Stewardship in which these two fundamentals are properly balanced for the mutual benefit of the three great interests involved becomes more and more one of the great needs of society.

Fortunate it is for this nation that during years of peaceful development of industry there grew up a body of men who had skilled themselves in the art of management, for without these men the task of wartime production would result in a hopeless muddle of conflicting interests and cumbersome un-co-ordinated groups of workers. Fortunate, too, it is that many men possessing these extraordinary skills have been able to detach themselves from the smaller individual tasks of private enterprises and undertake the larger tasks of industrial leadership with quasi-governmental status. We have here an example of the kind of statesmanship the world needs today in waging war and assuring the ultimate victory. We have here also the foundation of a larger statesmanship that will be needed when that victory has been assured and the world turns once again to a peacetime economy. Just as engineers taught themselves the technique of production, which is fundamentally independent, in so far as securing results is concerned, of the nature of the product, so also engineers and businessmen have schooled themselves in the technique of managing enterprises according to a pattern that is independent of the products of those enterprises. If we hold fast to these fundamental principles—those by which production and management are successfully prosecuted—we shall have little to fear of our ability to use them successfully in whatever peacetime economy ultimately develops.

To consider briefly that other aspect of successful enterprise—markets—we recognize at once that here again the art of management is needed. Today the major market is the war, but it, too, cannot be successfully served without that knowledge of co-ordinated human effort which starts with raw material and ends with delivery of manufactured products to the firing line. Here, too, is the larger task of co-ordinating not only our own requirements but those of our allies also. Perspective and planning become world-wide with an objective that transcends in importance the individual interests of millions of citizens as well as dozens of nations. Here, again, we find ourselves on a proving ground where we shall, if we are wise, learn how to relate millions of individual interests with those of the nation—yes, of the world—as a whole.

So it is that the principles of effective management, starting with the roots of small enterprises and individual interest, blossom and bear fruit in the greatest of all enterprises, the conduct of human affairs on a world-wide scale. The ultimate peacetime markets for the products of enterprises, no matter how small or how large they may be, must be discovered and served by means of an application of management on a grand scale. Those who will find themselves in positions of responsibility in this sector of our economy will have to add to their knowledge of engineering methods of work and their sensitiveness to human values a truly statesmanlike comprehension of the trend of events in their own localities, the nation, and the world at large. Just as today we find conspicuous examples of engineers who are high in authority in directing our wartime economy on the basis of what they learned in the management of their own individual enterprises, so also we shall find many more who will devote their skill and intelligence problems of government and international affairs. Surely this will be a gratifying extension of the art of management in which engineers will wish to exert a directing influence.

A.S.M.E. Aviation

MEMBERS of The American Society of Mechanical Engineers have had occasion to note with satisfaction an increase in the activities of the Aviation Division, formerly known as the Aeronautic Division.

Among engineering groups that paid attention to aviation developments after World War I and provided a means, in engineering meetings and publications, for the exchange of technical information growing up around an infant industry, the A.S.M.E. played an important part. With an active Aeronautic Division and a publication, part of the Transactions then known as *Aeronautical Engineering*, papers were presented and published in surprising numbers.

Today, scientific and engineering interest in the airplane and related industries and services has greatly multiplied the number of groups and publications concerned with these subjects. The essential relationship to mechanical engineering of the fundamentals on which these subjects are based has not changed in kind, even if it has multiplied in degree. In the fields of design, manufacture, service, and operation, the scientific and engineering principles involved are still those basic to mechanical engineering. Moreover, the interdependence of this new industry and its related services with other industries and services in the parent field still exists. For in addition to contributions which aviation makes to engineering, there exist also the contributions which mechanical engineering makes to aviation, and upon both of these continued progress depends.

For these reasons the growing activity of the Aviation Division, noticeable recently in meetings and publications, justifies the quarter century of attention the A.S.M.E. has devoted to aviation and promises even more fruitful contributions for the future.

ENGINEERS ARE THINKING PEOPLE

By JAMES W. PARKER

PRESIDENT, THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

It was appropriate that the A.S.M.E. at its 1942 Semi-Annual Meeting in Cleveland, held six months after Pearl Harbor, should be addressed by its own president and a representative of the British Government whose long service in many parts of the world, the British Empire, and the United States of America has given him an understanding of men and nations. Not in the spirit of boastfulness or of vengeance or of self-righteousness or of self-praise did Mr. Parker and Sir Louis Beale speak of engineers, but in the spirit of humility and in the realization of the serious responsibilities placed on engineers and the United Nations in their common objective of winning the war and of building a just and lasting peace.

AFTER every period of troubled stress through which the American people have gone within the last generation or two, we have wondered to ourselves whether at last America had grown up. It was so when we emerged from the first World War in 1918 and people were saying confidently, "America has come of age." I suppose they were asking themselves the same thing after the Civil War. But America had not grown up.

The war of 1917–1918 had been a sobering enough experience and one might be forgiven for believing that the young nation was at last approaching maturity. But in the 1920's we seem to have reverted to the antics of our unruly youth. And when times were hard in the 30's and the depression was upon us, we were swept with almost childish fear into national conduct which was anything but that of an adult people.

Now we are in the midst of a new experience which will try the stamina of this nation. This time there are signs of a new spirit, a new attitude of mind as we approach the test. One is struck with the earnestness, even the thoughtfulness, with which our young men go into the country's armed forces—with a smile—yes, of course, but not as in other wars in a spirit of adventure merely. They are going into this job with an understanding of risks and consequences characteristic of the thinking of a mature people.

It is not less so with our industrialists. We hear no talk this time of "war babies" and war millionaires. The industrial organizations of the country are taking their job of converting to war production more with a sober sense of a duty to work productive facilities to their utmost than with the thought of great profits.

As for the response of our own engineering profession to the stimulus of present circumstance, it has been like that of a rather young vigorous man of more than ordinarily strong physique. Its organized societies have not gone off on tangents along new lines of endeavor but have experienced rather a speeding up of their normal peacetime activities. Innumerable meetings have been held for the discussion of pressing problems confronting industry as it turns its hand to the new techniques of war production. Our own Society has responded invariably to the demands made upon it and taken its share in the rapid dissemination of skills and knowledge required in the period of reorientating the nation's manufactures. In their national organizations and as individuals, the engineers of the country have risen to this new opportunity of service to their people.

But there is a greater duty to be thought of if this nation is to play a major role in the world after the conflict is over. Our youth are doing their part in battle. We have had very prompt evidence of the soundness of their courage and their utter devotion to our cause. It is of the duty of our older men I am speaking, the duty to keep our hearts stout, to look into the future with intelligent courage and not flinch at the responsibility which will surely be ours of enforcing a world peace.

I have little patience with something which has too often been said of the engineer—that having brought on us the complexities of modern times with his achievements in the world of machinery, he alone can extricate us from the complexities which have ensued. But engineers who are worth their salt are a part, and an important part, of the trained, matured, thinking element of our population. As such they must think the nation's problems through on a scale commensurate with the size of the task.

Blunders and confusion are the inevitable consequence of years of complacency and unpreparedness. It has always been so with this people. But if we waste too much energy and time thinking of the ineptitudes of the government in Washington, we may forget that the task is colossal in scope.

The engineer is by long experience habituated to altering the scale of his thinking and he must do so now. It is as if we had been looking at the everyday aspect of things through a microscope. What we have seen is the disorder and confusion of minute particles of an enormous system. On a larger scale the significance of that movement is not that of its disordered particles but rather the progress of the entire swarm. The concept is an old one in engineering thinking.

This is certain—that the course of events during the war and after will be shaped by public opinion. The people of this nation will have to make what our great friend Dean Sackett calls "mass decisions." It is the responsibility of the trained thinkers of the nation to guide people in the making of these decisions, to influence the thinking of simple people through whatever community of interest contact can be established. That, as I conceive of it, is the duty laid upon engineers in the present time of trouble. It is their paramount responsibility to the country.

Delivered at a dinner at the Hotel Statler, Cleveland, Ohio, June 9, 1942, during the Semi-Annual Meeting of The American Society of Mechanical Engineers.

MEN AND MACHINES

By SIR LOUIS BEALE, K.C.M.G., C.B.E.

CO-ORDINATOR OF EMPIRE AND ALLIED REQUIREMENTS, BRITISH SUPPLY COUNCIL IN NORTH AMERICA, WASHINGTON, D. C.

MR. CHAIRMAN, Mr. President, Ladies, and Gentlemen: And especially ladies—for a society of engineers sounds so cold and efficient and hard, like the steel they use, and I feel that the presence of ladies tonight redresses the balance and helps us to look at life more fully, more completely. It helps us to look at the world as a world of men, women, and children, not merely as a maze of machines. War today is *total* war—a war that affects every man, woman, and child in this and every other country. In our daily talk of tanks and guns and ships and planes we are liable to forget the human beings whose life and happiness are the real objects for which we are all fighting.

I am greatly honored that you should have invited me to be with you tonight, and, as I say, the presence of ladies adds to my pleasure as well as yours. But ladies, your presence does pose the question, What sort of a meal do your minds want when the calls of appetite have been so charmingly met by this excellent dinner? What would you like? Something light and fluffy—just pretty compliments to the U.S.A.?—or something gritty, like statistics of factory output?—or something meaty which will give the mind food for thought and strengthen us for the task ahead, both for men and for women?

I wonder if it is difficult for engineers or wives of engineers not to think in terms of machines, and indeed of men as part of machinery. I remember when technocracy was a fashionable doctrine. The engineer was to run the world; he would organize everyone's life; his machines would do away with all unnecessary labor—nothing, in fact, would be done by hand. It was true that the engineer was then beginning to rule the world, to organize mass production and the use of machinery. There was a danger that he would be regardless, or rather forgetful, of human values and of the things that really make life worth living—truth, beauty—things of the spirit. Where does the engineer stand today? What is war teaching us? What lesson is the war teaching us which we must remember in the peace we look forward to?

Let us look back at those prewar days for a moment. How were the engineers planning the world? They were thinking in terms of more and more goods to be produced, cheaper and cheaper; hours of labor were to be cut down correspondingly; the world was to be a place where there should be an abundance of leisure and an abundance of necessaries and, indeed, of luxuries for everybody.

Had the engineer forgotten something? He had forgotten the harm that a few evil men can do in the world. He had forgotten how easy it was for a criminal with a gift for leadership to lead the common people astray. How many of us took for granted that another war was impossible, that, at all events, nothing could touch this great country protected as it was by two oceans? And some in Britain felt the same way about our own little island. And so we—both of us—slipped into the war unawares. We had concentrated our technical skill on the arts of peace (not very efficiently if one took a broad view of the whole world), and we had failed altogether to realize the danger of war. War came on us unprepared, unprepared physically and spiritually. From that unpreparedness we have suffered for two and a half years. We were not ready for the war of production, for the war of transportation, or for the war of combat. The critics, I believe, attack the governments always, in times of war, with the cry, "Too little and too late." Whose fault was it that Britain was unprepared, that France was unprepared, that America was unprepared?

In a democracy it is the fault of the people, not of the governments! By and large a country gets the government it deserves.

And so for two and a half years the tide of battle has ebbed and flowed. The story has always been the same—not enough tanks, not enough planes, not enough ships. Gradually we are making up the leeway; gradually we are meeting our enemies on equal terms. The engineer has now got the chance to do his great part. And splendidly the engineer is doing it. The production of instruments of war is a necessarily slow process. It was only in 1941 that the change-over to the full production of planes of present wartime design was begun in the factories and it is only in this year that the new models are seen in service in substantial numbers in the squadrons. Of course, I don't mean that no improvements have been made in modifying existing types, but the Spitfire Mark V and the Hurricane Mark II are only modifications of the original Spitfire and original Hurricane. The fact that your Airacobras are being flown direct to the battle fronts is, perhaps, the most striking advance of recent months.

Ebb and flow, flow and ebb. It is only the unconquerable spirit of man, the love of liberty that seems part of the soul of every true man, that has stood up to the flow of evil that has threatened now for three years to engulf the world. What has stemmed that flood? As much as anything else, the brave men and women who carried on beneath the hail of German bombs in Britain in September, 1940.

And the fighters in the air who broke the power of the German air force? Yes. But I honor equally those unsung heroes of London and Plymouth and Coventry—plain men and women who faced death and mutilation under intense bombing rather than surrender.

THE PRESENT

But let us glance around at these various fronts today. Now that the engineers are coming into their own, everywhere we see mechanized warfare, but everywhere also we see human skill, human courage, human endurance, human fortitude. Sometimes I wonder whom I admire most among the fighting men. Personally, I put in the front rank the ground crews, officers and men, engineers and mechanics, who are servicing airplanes and tanks in the Libyan Desert. No air-conditioned factories for them, probably not enough tools, no shade, the temperature running to 120 degrees, and always the chance of hostile attack from the air. The work goes on, night and day. Not enough water; enough rations, perhaps, but every mouthful has to be won after a battle with flies. You gentlemen can picture better than I can what servicing an airplane or tank means in the desert where the only hangar—the only workshop—is perhaps a tent on the sand. Upon the absolute efficiency of the machines depend the lives of the men who fight them—depend also the very results of the battles.

An address delivered at a dinner at the Hotel Statler, Cleveland, Ohio, June 9, 1942, during the Semi-Annual Meeting of The American Society of Mechanical Engineers.

It is true that in Britain today the ground forces of the R.A.F. are not harassed by German bombers as they were last year, but to organize these great sweeps of more than a thousand planes over Cologne and Essen there are perhaps a hundred thousand men nursing these big bombers, feeding them with gas and bombs, going over their intricate machinery to insure that all is working smoothly. Before the Essen raid, some of our men had been working forty hours at a stretch, continuously. They may not have the thrill of joining in the long procession majestically sweeping over the sky to Germany. They don't run the risks from antiaircraft fire and hostile planes, but it is their work that helps bring victory nearer.

We know the time will shortly come when American machines with American crews will join their British comrades in the air over Europe. We know they will show the same devotion, the same courage, the same technical skill.

I say we *know*, because American soldiers, seamen, and airmen have already proved their worth in so many quarters of the globe. We know what American soldiers have done in Corregidor, what American sailors did in the Battle of the Coral Sea, what American airmen are doing over Burma and in China. There, in China more than in any other theater of war, do we see how the great human virtues shine resplendent, when equipment is far inferior to that of the enemy.

You will notice that these examples I have just quoted are taken from events of the last few weeks. But one short year ago the whole of Southeastern Europe was being overrun, despite the gallantry of the Greeks, by the armies of the Germans and the Italians, fully equipped with every known instrument of warfare. But the gallantry of the Greeks and their allies was not wasted. The gallant resistance in Greece and Crete upset Hitler's timetable, with the result that his invasion of Russia was made six weeks too late.

Six or seven months ago Japan was bowing from the waist in Washington and at the same time piling up stores of war material in preparation for her treacherous attack of December 7. A year ago "too little and too late" was still true as the war spread to the Pacific. But now at last we see Americans fighting with equipment equal to that of the enemy—with a courage, a skill, and brainwork that makes the final result certain—Midway—the combined triumph of American Navy, Air Force, and Marines.

Thank God your factories are now beginning to approach the output needed. Things *are* changing. Never again shall we, the United Nations, be obliged to trust to courage and endurance alone without the tools with which to fight.

Behind the firing line in these factories in which you gentlemen—the mechanical engineers—stand as the officers in the great army of production, what are the qualities we need today? Is it *only* engineering skill, *only* mechanical proficiency, *only* inventors' genius? No, you know as well as I do that it is morale that counts—morale in all your great work.

Are we superior to our enemies in technical skill and in inventive power? To me this is a basic problem of the war. If free men, working with free minds in a free country, can't think better and work better than slave men with enslaved minds, in a slave country, then our boast of democracy is not worth having. Do you believe that the men of science, dragooned by Hitler in universities where freedom of thought is forbidden, can produce better results than the men of science in universities of Britain and the United States? Do you believe that the engineer who has to click his heels to every Gestapo policeman that skulks around his factory can produce a better output than one of you? Do you think it improves a man's work to be treated like a dog? To be forbidden to listen to foreign radio? To be frightened to whisper his opinions, even to his wife and children? To be deprived of the right to worship the Almighty in the way he thinks best? If you believe, gentlemen, that slavery of body, mind, and spirit makes a man and woman better human beings, better for work as well as better for play, if you believe that, then what are we fighting for? I believe, and I know you believe with *absolute confidence*, that we can beat the Germans in factory and workshop as well as we surely shall on the field of battle. I believe we can do it because we are free men, fighting for the cause of freedom. Morale—morale—*morale*! I believe that *this* is the true foundation of morale—that every one of us shall think of his opposite number in Germany, be he scientist, engineer, draftsman, greaser, cleaner, or oiler. Let him say to himself, "I am a free man. I can do better work than the guy who is doing the same sort of work in Germany and I'll show him!" Preach that in the factories, gentlemen—preach that in the factories, and don't fret about what any external influence may tell you you ought to do. Don't feel your patient's pulse every twenty minutes. The heart of the American people is sound. There are too many experts wandering around equipped with stethoscope and cardiometer.

I have said nothing about appealing to fear, to the immediate danger to life that falls not only upon my countrymen and millions throughout the world but quite possibly on your own countrymen. That danger, as your own leaders assure you, is very real. Even if this fair city of Cleveland were never bombed, the danger to your everyday way of life as well as to your country is just as real. Look at Poland today, at Norway, at Belgium, at what was Czecho-Slovakia! Hitler's plan is real—to enslave the whole world. And so within us all must burn with white, consuming heat the hatred of tyranny, the love of freedom, and the will to work and the will to fight! Thus only shall we survive, shall America survive, shall the United Nations survive. Our victory—the victory of the United Nations—is the condition of all else, of all that we cherish.

It is a common phrase to declare, "This is a war of machines." That is not true. It is a war between men, between ideas, if you will.

It is a War of Production, a War of Transportation, and a War of Combat. And in production, transportation, and combat we see constant changes occurring in grand strategy and in tactics as the war continues.

Let me give you an example of the changes in the strategy of the war of production. This is the age of the "interloper"—men who break into old industries and do the job better and faster than it was ever done before. You all know how Mr. Kaiser is producing ships on assembly lines, introducing mass-production methods at a time and in a sphere where they are urgently needed. He is the sort of "interloper" we welcome with open arms!

But it is from England that I can give you the most interesting example, I think, of the disappearance of competition between firms in the same industry and a "pooling" system under the control of a parent company.

I doubt that any of you have ever heard of Messrs. Rawson Limited of Tunbridge Wells. Tunbridge Wells is my native town, and I knew it as the abode of elderly spinsters and rich city gentlemen who used to go up to London comfortably after breakfast and return comfortably in time for dinner. I bought a car from Messrs. Rawson in prewar days. Now I have just received from a reliable source some account of what Messrs. Rawson, who operated a large garage in Tunbridge Wells, are doing in the way of war work.

They have brought into active and continuous production 100 small firms in the neighborhood (chiefly garages), of which 52 employ less than 10 persons, 36 between 10 and 25, and only 17 more than 25.

The group has completed most satisfactory work on gun carriages and ammunition. They have produced shells, bomb parts, small arms, gun and carriage parts, including 40-mm Bofors and 3.7-inch antiaircraft-gun parts. Reports of the inspectors are excellent. Rawsons' are now unable to accept all the work that is offered them. The turnover has risen from nothing to $50,000 a week. Ninety-nine per cent of the work passes inspection.

The output is secured by relatively unskilled workers and simple tools. Of the 2000 employed, 1300 are women and 700 men; 1800 are unskilled and 200 skilled. Many of the small shops are working three shifts. All responsibility for finance, accounting, and inspection rests with Messrs. Rawson, a garage in a once peaceful little country town of some 35,000 population.

It is this sort of co-operation in industry that enables me to give you good news of how production in Britain today compared with the output in those feverish summer months of 1940, the days after Dunkirk. Here are some comparisons—first of all, tanks. We are turning out twice as many today as we did in August of last year; three times as many as in February, 1941; and five times as many as in July and August, 1940. This achievement means more if you remember how difficult a tank is to build. We had to make the best of what we had got. So the tanks of the type we needed were broken down into eight thousand bits and pieces; and then 6000 firms, ranging from big plants to backyard garages, were enlisted to make one or more of those 8000 parts.

Let us turn to the War of Transportation. Again we see new methods of attack and defense developing as the war proceeds. On the side of attack there is the pocket submarine and the long-distance bomber; for defense the submarine chaser and the long-distance reconnaissance plane. Despite the gloomy news that confronts us daily, I believe we are winning the war of transportation, winning it slowly, it is true, but winning it surely. We shall win in the end, even though we may have to draw in our belts in this country—not as tight as they are drawn in Britain, but still, pretty damn tight.

We are losing shipping very seriously along the coast of this country. Across the Atlantic and in the Arctic Ocean we are doing fairly well. In the Mediterranean and the Pacific, our enemies are doing worse than we are. There is another side to transportation—the railways. I wonder what trainloads the traffic superintendents in Cologne and Essen are dispatching this week? Is the freight yard at Cologne a traffic yard or a junk yard? I wonder how far supplies to the German army are running steadily up to the Russian front? So, as we take a hurried glance around the whole world, it seems to me that the battle of transportation has also its ebb and flow. Remember, the losses are not all on our side. Still, ocean transportation remains a very serious matter for us—very serious indeed.

And the Battle of Combat—have you noticed how the military experts have been consistently wrong for the last three years? Did anyone believe that China could have withstood the onslaught of Japan for five years? Whoever imagined that the Italian Empire in Africa would fade away before the attacks of a few thousand British and Belgian troops? Are you aware that a Belgian colonel at the head of two battalions picked up seven Italian generals and their men as their prisoners? Whoever prophesied that the Italian air force, the "regia aeronautica," would crumple before the British flying men? Did anyone believe that Malta would hold up against 1500 raids? Of all the bubbles burst in this war, Mussolini's toy balloon has made the most astounding pop of all. But take two of the more important combatants, Britain and Germany, and the judgment of the critics upon them. It is twenty months since those critics prophesied the destruction of Britain within six weeks. Or take Russia—the magnificent. It is only ten months since the critics declared that the German army would cut through the Russian like a knife through butter. You would not expect me, a poor humble civilian, to evaluate the military position today. I am not guessing whether Japan proposes to invade India, or Australia, or to endeavor to complete her conquest of China, or how far the attack on Alaska is merely a piece of bad psychology, an effort to frighten the American people. I do not propose even to discuss the possibility or probability of opening up another front. Of course, we should all like to see it, but possibly you know that it takes fourteen tons of shipping to transport each single soldier with his equipment across the sea. I am thinking, of course, of a fully equipped army and not just the gallant little commandos with their wasplike attacks on German posts. I do not know the answers to any of these military questions, gentlemen. Quite honestly, I have too much to do in my own job and it leaves no time to inquire into such questions. All we civilians have too much to do to inquire into such questions. If we do our own jobs properly, we shall have no time to tell the generals and admirals how to do theirs. All I know is that we, the antiaxis nations, are united as never before, that our purpose is firm, that we have won the battle of production, that we are winning the battle of transportation, and we shall win the battle of combat.

This war has taught us, I think, that a mere mechanized world is a hollow dream. We know it is man that matters. We are bound to use machines to assist him, even in the most devilish of all tasks—the destruction of his fellow creatures—but we have learned quite definitely that man must remain the master—the machine must be his servant. Courage, brains, and endurance will win this war—courage, brains, endurance, and sacrifice in the firing line and behind the firing line. There are in Great Britain 33,000,000 people, men and women, between the ages of 14 and 65. Out of those 33,000,000, twenty-two million are directly engaged in war production. These figures speak for themselves; they tell you what life is behind the firing line in Britain.

And after the war we shall need, perhaps, more brains, more courage, more endurance and sacrifice. What will the engineer do? How will he control his machines when victory comes? How can we use this amazing power of the engineer over nature, these aids to human progress? Let us consider the future as we see it and the tasks that will lie before the engineer.

THE FUTURE

You have doubtless pondered in your minds this problem of postwar reconstruction. You have visualized these huge plants now devoted to war work. You have seen in your minds the possibility of machinery lying idle and the men out of work. You have thought, too, of the millions of soldiers—four and a half million for this country alone—longing to get back to civilian life, unsettled, of course, and feeling that they have suffered and that now they have a right to reap the fruits of Victory and the blessings of Peace.

Have you thought that the same will be happening all over the world? How many men are there today under arms? Shall we say fifteen million? Shall we say thirty million? And how many are there engaged in war production? Shall we say 300 million? And how many women are there thus engaged? Millions! In Britain today there are a million and a quarter women working in the airplane factories alone.

All human beings the world over have got to be helped back to a reasonable human existence, if we and our children are ever going to enjoy peace and contentment. Most certainly, we shall not leave the Germans and the Italians and the Japanese free once again to form plans for world conquest. Never again

will we allow a Hitler or a Mussolini or a Hirohito to weave their loathsome plots, to plan treachery, to prostitute science to the insane desires of men drunk with power. No, ladies and gentlemen, we have learned our lesson. Even if it takes a hundred years of watching under arms, we will see to it that such villainy shall never be permitted again upon this earth. We shall remain armed watchers over the peace of the world until the hearts of these people, these Germans, these Italians, these Japanese, are cleansed from the evil infection that now corrupts their very souls.

Do you ask me how we shall plan the world anew? The time is not ripe for blueprints. We can only sketch the very broadest outline. Let us try to establish three or four basic principles for this world of the future Firstly, we must recognize the inherent equality of man. I don't mean that all men are equal in body and mind. You know as well as I do that they are not, but I do believe that in our new world we must give all men equal opportunities—above all, opportunity for freedom. Once, we used to talk of the white man's burden—the duty of the white man to guide, to control, to give justice to the "lesser breeds without the law." That idea is dead. All the men and women of all countries will claim freedom as their inalienable right. Millions of the peoples of the United Nations have fought and suffered and died for this cause. And when our allies sit with us at the Council Table of the World, they will say, "We have fought, we have suffered, we have spilt our blood in the same cause as yours. We have shown ourselves as men."

Dare we of the Western World then say to these, our Allies, "But look at *our* machinery! Look at *our* factories! Look at *our* conquest over nature! *We* have been the pioneers of progress, the standard bearers of civilization." I fear, gentlemen, that the answer may leave us speechless. "Look where your civilization has led us all." In all humility, *then* shall we gather around the Council Table. In all humility, but with infinite courage, we shall join in the greatest task of all, to plan the world afresh.

Think again for a moment of the Council Table of the World —when Victory comes.

The English-speaking nations will be there. Britain with her age-long traditions and long colonial experience, America with her stalwart frontier spirit ever burgeoning within her and her genius in industry, Canada with space and spirit for a great nation, Australia and New Zealand, the testing grounds for social experiments, South Africa with her problems of 7 million colored to 2 million white. Europe will be there—maimed, ravaged, ruined Europe—blazing with hatred for her tormentors. South America will be there. China will be there—China the heir of thousands of years of civilization. India will be there—India at the parting of the ways—wondering whether to westernize or to hold fast to her old traditions. Russia will be there.

The representatives of 1500 million human beings victors united in war—united in Victory—all will be there. Shall we remain united in Peace? The bonds that unite us have been forged in the furnace of suffering, tempered by the tears of starving women and children, hallowed by the blood of heroes. These bonds will hold us together, until we are certain beyond peradventure that never again shall greedy tyrants, for their greed and their selfish ends, engulf our world in war. For it is *our world*, the world of plain simple men and women who have borne the burden and heat of the war. *It is our voice*, the voice of the people of the whole world who will say, "*Never Again.*" Let the rulers beware if they do not take heed. So far we shall remain united. But in shaping the New World will our unity stand the strain? Yes—we must and shall be united in peace.

We are all bound by the Atlantic Charter. What has been promised by the Atlantic Charter? Economic equality, that is, access to raw materials, an approximation to freedom of trade. The corollary is sure and certain. It is a hard gospel, but I believe it is inevitable, that all nations and all industries within nations must live by merit and not by favor. That means brains, courage, endurance, and sacrifice.

The elimination of large-scale unemployment must, I think, be undertaken by some form of international action. The great manufacturing countries such as the United States of America, Britain, and Germany have largely solved the problem of mass production. But have they solved the problem of distribution? With maladjusted distribution comes loss of purchasing power and corresponding unemployment. Somewhere we must cut into this vicious circle. Somewhere we must insure that workers are no longer left to starve amidst plenty, that those ready and willing to use their hands and brains shall not become centers of righteous discontent against a system that fails to provide a living.

You will notice that I take unemployment as a basic problem in postwar reconstruction. What a man wants, be he white or black, yellow or brown, as his due reward for work well done, is *security*, freedom from fear, from fear of sickness, from fear of old age, from fear of poverty and want for himself, for his wife and children. That security, that freedom from fear is only possible in a world considered as a whole. We know now that it is futile to think of half the world as happy, content, and prosperous and half the world as idle, angry, and poor. We must try to give this security, this freedom from fear, to all the peoples of the world—not just to our own peoples. Indeed, unless we tackle the problem of unemployment as a world problem, no nation itself will be free from the curse of unemployment—we must all be well or many of us will be ill, in the economic and social sense Do you realize the poverty of Southeastern Europe?

Do you realize that a Bulgarian or a Rumanian peasant has perhaps five or six dollars a year with which to buy goods that are not produced on his own little farm? Do you know how millions of Chinese along the Yellow River are in constant danger of seeing their livelihood swept away by sudden floods? Do you know what riches await the world in the Amazon Valley if only science and engineering skill could be applied to that rich area? It is in tasks such as these that the engineer will play his part in world reconstruction. Some international body, perhaps an international bank, must provide the capital, but the engineer with his European and American knowledge and skill will build and supervise these giant plans that will give security to the poverty-stricken peoples who live today in constant peril of starvation and destruction.

Far be it from me to suggest that every nation shall become industrialized, that we wish to see China dotted with factories, to see the primitive arts of Java and India swamped in a flow of mass-produced goods. I do not believe that happiness consists merely in collecting property.

What then is the task of engineers in this brave new world of ours? First and foremost, his profession gives an outlet to the adventurous spirit of man. We shall need it more in a world of peace than in a world of war. It is a spirit that we must foster. It is a spirit we must sublimate—we must turn it to a higher cause than the destruction of one's fellow men.

The engineer and the scientist have their great adventures in the search after truth, in the conquest of nature. There are victories to win over famine, over flood, over drought and pestilence. The engineer can relieve men—*all men*, not merely his own countrymen—of dull, laborious toil.

From that toil, the engineer does save, can save, and will

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INDUSTRIAL TRUCKS

Effect of Floor Conditions on Power Consumption and Tires

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USERS as well as manufacturers of industrial-plant trucks are interested in data on the effect of rough and smooth floors on power consumption for the trucks, as well as the effect of these floors on the tires and on the trucks.

The author's company has run a great many tests on power consumption in different plants throughout the country, but because of the nature of the tests we have never been able to obtain any accurate data on the specific rolling resistance due to a particular character of floor. Our tests in general have indicated the performance of a truck in a complete day's duty cycle, and in this connection we find extreme variations because of the character of floor surfaces over which the truck must run.

Where a great deal of yard work is encountered the power consumption runs very high when the truck must operate over unpaved and particularly softer roadbeds. We have also found that on rough flooring such as exists in older steel plants the power consumption per hour of operation will run considerably higher than in mills which have smooth flooring. Railroad crossings will also add considerably to the power consumption in a day of operation. It is impossible, however, to determine the direct rolling resistance by a dynamometer or other means. It is rare to find a floor sufficiently level to give consistent readings.

We have used hydraulic dynamometers between the vehicle to be tested and a tractor, and these readings on a floor that is apparently level will vary from 0 to 10 times their average value. In other words the readings are so erratic as to make dynamometer readings useless even though the dynamometer be heavily damped such as is possible with the hydraulic system.

METHOD OF DETERMINING ROLLING RESISTANCE ON TIRES

In determining the rolling resistance on tires and on wheels of various types, we selected an upper floor in one of our new buildings for the tests. This floor is practically level. The procedure is to pull the truck forward by a cable which is run out of the window and over a ball-bearing sheave on a bracket attached to the building. The cable then runs down and is attached to a bucket containing a ballast weight. Weight is added to the bucket until it is sufficient to draw the truck across the floor at an approximately uniform rate of speed. This test is repeated about a dozen times and average values obtained for each different type of tire under test. A test would not be entirely accurate if the floor were not absolutely level, or if it did not accurately duplicate conditions found in industrial plants. Considerable time and expense would be involved in making up samples of different types of flooring to develop such a test.

Generally speaking, we find that smooth concrete offers considerably less friction than a sharp-tooth rough concrete. We also find that where there are deep cracks or ridges in the concrete they add materially to the power consumption, as well as shorten the life of the tires and the vehicle itself.

On good wood flooring we find little variation from the friction required for smooth concrete. When wood flooring is uneven, and particularly when it is not well supported so that it springs as the vehicle is driven over it, the friction is likely to run up to 2 to 1. We also find a considerable increase in power required when running crossways on poorly laid boards, as compared to running with the grain or at 45 deg with the grain. Wood flooring, however, is usually less destructive to tires, unless it is rough and poorly laid. The most destructive condition for rubber tires used on trucks comes from running over sharp edges, either of concrete or railroad-track crossings. This is particularly true on vehicles that are loaded to full capacity or possibly slightly overloaded, as a crack in the pavement tends to cut the rubber at one point and eventually loosen the bond between the rubber and the steel rim.

In some plants where paving is particularly bad, and where it is necessary to cross railroad tracks, the tire life will be shortened to one third of normal. Here we find a characteristic type of tire failure, i.e., loosening the rubber from the rim.

Another type of flooring sometimes encountered is mastic. This is more or less equivalent to asphalt in its texture and subject to some degree of softening particularly in hot weather. This type of pavement is particularly bad from the standpoint of power consumption, sometimes running double the friction found on ordinary concrete. In addition, the heavy tire loading encountered in trucks will soon wear ruts in the material and further increase the power required, as well as require replacement of the floor itself.

On applications where hand trucks are used in addition to electric-power trucks a further effect is introduced in connection with flooring, due to the fact that a great many hand installations employ steel wheels which are very destructive to concrete floors, particularly in locations where the traffic is concentrated as through certain doorways. Where steel-wheel hand trucks are operated to any great extent it is always desirable to employ a wood-block or other type of floor to withstand the pounding of the solid-steel wheel. The other alternative is to change over to a noncutting type of wheel such as rubber or synthetic-plastic compounds. Where hand-truck traffic is light the concrete floors stand up satisfactorily even with steel-wheel hand trucks.

EFFECT OF TIRE COMPOSITION ON POWER CONSUMPTION

It is also pointed out that with a given type of flooring there is a wide difference in power consumption because of the character of rubber used in the truck tires. Our tests have shown a variation in power consumption of 2 to 1 between the extremely low-friction material and extremely high-friction material; and strangely enough the harder rubber compounds develop the highest friction.

In the past the tire companies made a special compound for industrial trucks which they originally called "electric compound" and later "power-saver compound." Because of the present scarcity of rubber and the high percentage of rubber re-

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COLD-ROLLED STAINLESS STEELS *in* AIRCRAFT

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THE object of this paper is to describe the properties of the cold-rolled stainless steels as related to lightweight high-strength structure and to discuss some of the more recent improvements obtained by slightly changing their compositions and by heat-treating to relieve internal stress resulting from cold work. The cold-rolled stainless steels have been used in building high-speed trains, truck bodies, truck trailers, airplanes, and similar structures, and during the last few years greater interest has arisen in the properties of the steels because of increased demand in the transportation industry for lightweight high-strength structures.

One of the retarding factors in the use of the cold-rolled stainless steels, particularly in aircraft structures, has been the lack of information on the stress-strain characteristics of the thin sections involved. Especially has this been true in the case of compression stress-strain data, which are required for designing airplane wings and fuselages. It has been generally accepted that the strength of these sections is limited by the strength of certain of the members that carry compression loads, and unless the compressive properties of the materials are known, it is impossible to obtain safe and economic design. Procedures have been developed for determining the compressive strength of the thin sections of stainless steels, and data are now available to the designer. No attempt will be made to describe these procedures as they have been reported on elsewhere (1, 2, 3),[1] but as previously stated, the data obtained will be discussed with special reference to the effect of the low-temperature stress-relieving heat-treatment (4) at 200–300 C (392–570 F) on the cold-rolled steel.

STEELS UNDER CONSIDERATION

The steels to be considered are the 18 per cent chromium, 8 per cent nickel steel; the 17 per cent chromium, 7 per cent nickel steel; and the 17 per cent chromium, 5 per cent manganese, 4 per cent nickel steel. All these steels are corrosion-resistant and are austenitic in character, which means that in order to increase their strength it is necessary to apply cold work rather than a heat-treatment that is required for raising the strength of ordinary steels or the ferritic types of stainless steels. One advantage of the cold-rolled austenitic stainless steels over the latter types of steels is that they are more suitable for spot welding, which facilitates the rapidity with which structures can be built. After spot-welding, the cold-rolled austenitic stainless steels have satisfactory resistance to corrosion.

The strength and ductility of the austenitic stainless-steel strip or sheet are largely controlled by the amount of cold work applied to them. In the annealed condition their tensile strength is on the order of 100,000 psi and their ductility is high as exemplified by the elongation values (60 to 70 per cent in 2 in.). As the percentage of cold work is successively increased, the tensile strength is raised and the ductility is lowered. In arriving at a set of useful properties it is customary to cold-roll the steels to a degree that increases their strength, but does not simultaneously decrease ductility to a point at which serious difficulty is encountered in forming sections that are joined by spot-welding. Recognition of this point has been one of the important developments in recent years on the cold-rolled stainless steels, and it explains why steels of the 18-8 and 17-7 types as well as the 17-5-4 type are referred to in the present discussion.

It is necessary to cold-roll the 18-8 steel excessively to obtain a very high strength, which results in low elongation and relatively poor compressive stress-strain characteristics. The early investigations showed that even though the tensile strength of the 18-8 steel was increased materially upon cold-working, the compressive strength was not increased in like proportion. This resulted in a wide variation in the tensile and compressive yield strengths in the direction longitudinal to rolling. From a practical standpoint this difficulty has been largely overcome by the development of the 17-7 steel (3, 5, 6, 7) which can be cold-worked to a greater degree without serious loss of ductility and without obtaining such a large difference in the longitudinal yield strengths in tension and compression. The application of the low-temperature stress-relieving heat-treatment at 200–300 C (392–570 F) reduces the difference in the tension and compression yield strengths of the 17-7 steel in the same direction to rolling. Similar properties are obtained in the steel containing approximately 17 per cent chromium, 5 per cent manganese, and 4 per cent nickel (8), so that when high strength is required excellent tensile and compressive stress-strain characteristics can be obtained in either the 17-7 or the 17-5-4 steel.

TENSION AND COMPRESSION PROPERTIES OF THE STEELS

Both tension and compression tests have been made on cold-rolled strip of each of the steels, approximately 0.035 in. in thickness, and the data are considered to be representative of strip varying in thickness between about 0.01 and 0.10 in. and cold-rolled to the same extent. The tests have been made in the direction longitudinal to rolling and in the direction transverse to rolling, both in the as-cold-rolled condition, and after cold-rolling and stress-relieving. The tensile experiments were made on strip samples using a standard-sized flat A.S.T.M. specimen and sufficiently accurate strain gages (metric Huggenberger gages, type A) to permit the strain corresponding to a given stress to be accurately measured. The compression tests were made using similar gages in accordance with the "cylinder method" (3) which consists briefly of measuring the compression characteristics of a cylindrical sample having a slenderness ratio of about 5 and a diameter-to-thickness ratio of about 40. In both the tension and compression experiments the loads were applied with a 60,000-lb Baldwin-Southwark testing machine. The gages were left on the samples until it was possible to determine the slope of the modulus line and the yield

[1] Numbers in parentheses refer to Bibliography at end of paper.

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